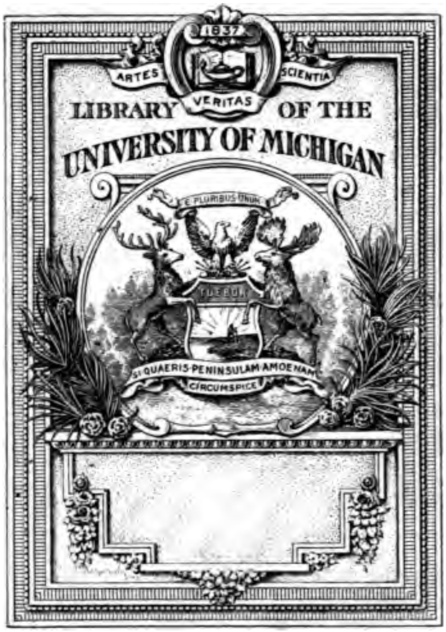
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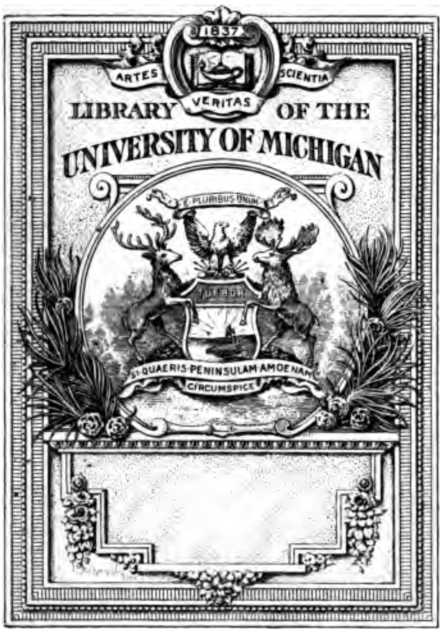
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TIMBER

AND TIMBER TREES

TIMBER

AND TIMBER TREES

NATIVE AND FOREIGN

BY

THE LATE THOMAS LASLETT

TIMBER INSPECTOR TO THE ADMIRALTY

SECOND EDITION

COMPLETELY REVISED, WITH NUMEROUS ADDITIONS AND ALTERATIONS

BY

Harry

H. MARSHALL WARD, D.Sc., F.R.S., F.L.S., F.H.S.

PROFESSOR OF BOTANY IN THE ROYAL INDIAN ENGINEERING COLLEGE, COOPERS HILL

London

MACMILLAN AND CO.

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Second Edition, 1894.

PREFACE TO THE FIRST EDITION

A HANDY-BOOK on Home and Foreign Timber, for ship and house building purposes, is, in the opinion of many, much required. The botanical treatises which are accessible are too strictly scientific in their form and treatment to interest the general reader, and they lack that practical application of knowledge to the wants of the shipwright and carpenter, which it is one of the aims of this book to give. Hence, I have endeavoured to concentrate into one form all the information which books and long experience could give, and so to arrange the materials as to make them intelligible and acceptable alike to the master builder and apprentice.

Keeping this in view, I have introduced into the work the substance of a course of lectures on the properties of timber, which I delivered at the Royal School of Naval Architecture at South Kensington;

and of three other courses of lectures on the same subject, delivered at the Royal School of Military Engineering at Brompton Barracks, Chatham.

Many new descriptions are treated of, and a great number of experiments on the strength of timber are given in detail as well as in the abstract. Further, there are some useful notes on seasoning timber for use, and the best means to be taken for its preservation.

THOMAS LASLETT.

58, MARYON ROAD, CHARLTON, S.E.
September, 1875.

PREFACE TO THE SECOND EDITION

WHEN the Publishers requested me to undertake the preparation of a New Edition of this Standard Work, I felt that an opportunity was offered for doing a valuable service to the professions and trades to which it appeals, by showing some of the numerous advances made in our knowledge of that remarkable structure, Timber, and the no less remarkable Trees that yield it, gained by the study of modern botany, and especially in its economic aspects, since the appearance of the First Edition of this work nearly twenty years ago. At the same time it had to be clearly understood that the work should not be altered in character to the extent of making it a formal text-book of theoretical science.

The question whether I should be able to set forth these matters in the limits of the book, and at the same time retain all that is best of the popular style and wide knowledge of his subject shown by

the late Author, was a serious one, because it was at once evident that I must almost entirely re-write some parts of the book, and make material alterations and additions in others.

I have, wherever practicable, retained the numerous Tables of Experiments and the Illustrations of the First Edition. At the same time, it should be noted that much has been done to advance our knowledge of the technical properties of timber since Laslett wrote, and the reader should consult the works of Bauschinger, Rankine, Unwin, Lanza, and others, for further experimental details on the strength of timber as building material. In this connection, I have especially to thank Mr. W. J. Luke for valuable suggestions and assistance in revising the Tables and calculations of the First Edition, and particularly corrections regarding the formulæ on p. 101 and the Appendix.

Those familiar with the First Edition will notice that I have completely altered the arrangement of the work in so far as to bring the timbers of the "broad-leaved," or Dicotyledonous trees together, as contrasted with those of the Conifers, in each case treating of them according to the part of the world they are found in. Important additions have been made as regards the timbers of India, Australia, the

Cape, Natal, and others of our Colonies, thereby, I believe, greatly enhancing the value of the work.

I trust, also, that those concerned will find the comprehensive additions regarding the general characters of timber and its uses, its defects, and the processes of preserving it of value.

Those readers who wish to go further into the literature of timber, and especially of the woods of our Colonial possessions, will do well to consult the various works quoted throughout the book, and to visit the Timber Museum at Kew.* I do not pretend to have enumerated all, but choice has been made of some of the leading ones, and I take this opportunity of acknowledging many obligations to the works referred to. In order to facilitate reference to the very numerous additions, especially among the timbers of our Colonies, I have prepared an index as complete as possible to all the names of the trees concerned.

In conclusion, while it is too much to expect that no omissions have been overlooked in a book requiring so much labour, I hope that few will be

* An excellent guide to this has since been published, to which I owe several corrections in the proof-sheets.

found of importance; but I shall be extremely obliged to any readers who will suggest improvements which might make the work even more useful than it is.

H. MARSHALL WARD.

COOPERS HILL,
December, 1893.

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TIMBER

AND TIMBER TREES.

Part I.—On Timber in General.

INTRODUCTION.

ON THE NATURE OF TIMBER, OR WOOD.

TIMBER, a word derived from the Saxon, signifies wood of such kind and size that it can be employed in construction, building and engineering works, ship and carriage making, carpentry, and for numerous other purposes, and a timber tree is one that yields such wood.

If, now, we take any convenient piece of wood of the kind mentioned, and submit it to the examination of various experts used to the investigation of natural objects used in commerce, we shall find their reports upon it differ considerably according to their *points of view*, and according to the *kind of training* they have received. The report of the carpenter will differ altogether from that of the chemist, that of the physicist will be of a kind utterly unlike that of the timber-merchant, and that of the engineer will have little or nothing in common with that of the botanist or of the forester, and so on.

Nevertheless, totally different as are the facts brought into the foreground by each of these investigators, there is a common substratum belonging to them all, and the best possible knowledge of what timber, or wood, is, will be got by comparing all their statements, and finding out what relations they bear to each other, sifting out what depends on inferences drawn from incomplete examination, and fitting together in their proper sequence all those which support one another.

With this end in view, I propose to give some idea of the kind of *way of looking at a piece of wood* which seems prevalent among various sections of professional and scientific experts who concern themselves with wood in one form or another.

Let us first examine the points of view taken

1. BY THE TIMBER-MERCHANT.

It will readily be understood that when our piece of wood comes into the timber-yard, from its forest home away in the hills, or beyond the sea, or wherever it was, the first tests to which it will be subjected are at the hands of the sharp-eyed, experienced man of business whose purpose is to sell or buy it; and when we reflect that—to say nothing of the vicissitudes to which it was exposed while growing in its native forest—the wood may have passed through many perils as it lay felled on the ground, or as it slid down the timber-slide, or was carried down the hills on sledges, or rolled helter-skelter into the river, thence to be floated, or carted, or carried by rail to its destination, it will be evident the expert who is concerned with buying and selling the timber must have his eyes open to many possibilities before he decides as to the quality of the wood he examines. We

will suppose that he chances to select as a sample some particular piece of wood.

In the first place, or at any rate after satisfying himself as to the species of timber concerned, he will examine the cut ends—the transverse section—and see what marks are there visible. He will probably make sure that the annual rings are of the right average breadth, and evenly grown without interruption: these matters are of some importance, and there are differences in detail required for each kind of timber.

He will at the same time assure himself as to the soundness or otherwise of the central parts, round the pith; for in old trees the inner portions of the heart-wood (the oldest of all) are apt to decay, and if this decay has commenced the timber-merchant must take steps to find out how far the useless portions extend into the log, and of what nature the decay is, because some forms of rotting are much more damaging and far-reaching than others.

He will also be on the look-out for various indications of damage only known to those who are in the habit of examining large timber. Certain fissures, or cracks, are very common in felled timber; and while some of these only extend slightly into the log, others, again, are indicative of serious defects which will cause great waste when the logs are sawn.

These fissures are mostly apparent at the cross section, especially of the lower parts of the log. Some of them exist before the tree is felled, but others only appear afterwards. Certain of these fissures occur in the direction of the radiating lines known as medullary rays, the wider part of the fissure being next the pith, while it narrows more and more as it extends outwards. If these "*Heart-shakes*," as they are called, exist to any

great extent, it is obvious that it will seriously affect the cutting up of the timber into planks, etc.

The principal cause of "*Heart-shake*" is the unequal loss of water, and consequent shrinkage, of the older (central) parts of the wood, owing to the incipient decomposition of that part and its consequent inability to retain its usual proportion of water in antagonism to the more powerful outer and younger parts.

Another form of radial fissure has to be carefully distinguished from the above. In this case the cracks are wider and wider as we trace them outwards—*i.e.* towards the bark. Many of these so-called "*Star-shakes*" are due to the more rapid drying of the external layers of wood, as the tree lies exposed on the ground, after felling; but there are other defects, also expressed by radiating fissures which look very similar to the last, to the inexperienced eye, but which are due to quite other causes, often operating while the tree is standing in the forest. The chief causes of these are violent changes of temperature, but their peculiarities in detail may be passed over here.

Finally, the practised eye of the expert will search for fissures which run in the planes of the annual rings, and therefore cause separation, more or less complete, of the layers. These "*Cup-shakes*" may be due to violent and sudden changes of temperature, or to the excessive bending of the tree before high winds, or to other shocks—*e.g.* the heavy fall of the tree or the log.

Nor does this by any means exhaust the list of possible defects in the wood, and to which the merchant will direct his keen attention. He will want to know whether the "grain"—*i.e.* the lines and planes of structure—runs straight in the log, or whether it is twisted, as is often the case in some woods. Then he will investigate

the sample carefully for any signs of discoloration, especially certain rusty-looking streaks which betray the presence of various kinds of "*rot*"; for signs of an undue proportion of "*knots*"—*i.e.* the buried proximal ends of branches long dead. Many woods have their own special odours; and the suspicious connoisseur will bring his olfactory sense into play to ascertain if the odour is characteristic, or if it is unduly overpowered by certain musty or sour smells which denote the existence of fungi, or insects, or chemical decompositions which may cause trouble.

Even the sense of touch is sometimes employed by the expert, though probably to a far less degree by the buyer of large timber, than by the more sympathetic cabinet-maker or turner.

2. BY THE ENGINEER AND BUILDER.

Those who use timber as material for construction, will naturally have a way of their own of criticising our piece of wood. The engineer or builder will be especially concerned as to the loads that pieces of given length and diameter will sustain; the amount of change it will exhibit in volume, by swelling or shrinking; the shocks it will endure and respond to elastically; and how long it will last when exposed to the vicissitudes of a variable climate or other medium.

The methods by which he gains the information desired are simple, and for the most part direct.

He subjects pieces of known length and diameter to various increasing strains. He finds that all woods offer resistance to strains or pressures applied in the direction of the longitudinal axis of the stem, or radially or tangentially across this axis; and he compares the

different species by applying the same tests to similarly cut samples of each.

He thus obtains empirical numbers expressing how many units of weight are needed to slowly extend or compress a bar of the wood, longitudinally, by so much of its original length; or how many units are necessary to bend it transversely up to such a point that it can, or can not, recover its original shape; or, again, to such a point that it snaps, and so on.

Since numerous trials convince him that different species differ in these respects, and that wood of the same species differs considerably according to its age, dryness, and the manner of its growth, he obtains long lists of somewhat rough data for his calculations.

By these means he arrives at numerical expressions for the average rigidity, elasticity, resistance to compression or shearing stress, to tearing or abrasion, and so forth. He also tests the resistance to torsion, to splitting, etc., and to the cutting power of various instruments.

Additional information is obtained by experience—another word for experiment if properly controlled and recorded—as to the durability of various specimens of wood after long years of exposure in dry air, or soil, or in damp media, or, finally, in an environment subject to changes in the degree of moisture. Some kinds of wood last a fairly long time if kept dry, which decay rapidly if exposed to damp; others, again, will endure for years if always wet, but soon rot if alternately exposed to moisture and to a dry air. Moreover, different woods offer different degrees of resistance to the attacks of predatory animals and plants; such as white ants and teredo on the one hand, and the fungus of dry-rot on the other.

The average weights of equal volumes of "green" wood, expressed in terms of a chosen standard, also afford him information of service; and when these are compared with the average weights of similar volumes of the same wood in a dry state, he obtains yet other data, which lead him moreover to approximate notions as to the quantities of water contained in the former. Comparisons of the changes in volume undergone by his specimens as they lose or absorb water also help him to estimate the capacities for shrinking and swelling which his specimens exhibit.

But it must be confessed that his methods and conclusions in this connection are very rough indeed; for, while on the one hand the same wood holds very different quantities of water according to the time of year at which it is felled, the soil on which it grows, and the climate in which the tree flourished, on the other hand the observations on dry wood have been usually recorded for "air-dry" specimens—*i.e.* specimens allowed to dry until they are judged to be dry in the popular sense.

Now it can be readily shown that such wood is never really dry, and that it gives off and takes up considerable quantities of hygroscopic moisture from the air; and there are many other fallacies at the bottom of these conclusions.

The same criticism applies to the weights of different pieces of wood, as given in the tables of the engineer and builder, etc. The numbers there found refer to pieces which vary in volume—because their volumes alter differently as the state of the atmosphere changes—and which contain different quantities of water—because different pieces of wood give up or retain different quantities of water as the state of the air varies.

However, given certain rough corrections, a sort of average is obtained for each kind of timber, that seems to satisfy the requirements of the practical man.

By noting these properties, and taking into account the relative hardness or softness of different woods; their freedom from resin or oil, and conversely; their tendency to warp, crack, shrink, etc., as they lose water in "seasoning"; and some other points which the expert is on the look-out for, the engineer or builder selects his wood for bridges, railway stations, sleepers, roofs, mills, piers, ships, and so forth.

3. BY THE CARPENTER, TURNER, ETC.

Here we have critics with somewhat different ends in view, and if we include the cabinet-maker, carver and gilder, and other specialists who work with smaller quantities of wood, the points to be examined in our piece of wood are numerous and various.

One essential will be what is called the "grain" of the wood; a term it is not easy to define on paper, but which refers to the kind of surface—rough, smooth, coarse or fine—left after the action of a tool. Some woods, for instance, have a beautifully smooth, even "grain," so that a sharp saw cuts directly through and leaves the surface compact and level; others, again, are apt to tear under the tool, and the surface is rough, or "woolly," with ragged ends of torn fibres. "Cross-grained" is a curious term, which refers to the fact that the fibres, etc., are so irregular in their course, that the tool is sure to meet many of them at a wide angle with their longitudinal axis at that spot.

The terms hardness and softness, and the word surface are used somewhat loosely, and are sometimes

confused with the above. "Silver-grain" refers to the distinct patches of medullary rays often seen on those surfaces which coincide more or less with the radial plane.

Since the workman has to think of his tools, and their edges, teeth, etc., as well as of the wood he uses, he comes to look critically at the relative hardness or otherwise of the latter; and the kind of surface—smooth, lustrous, silky, clean, mottled, etc.—he can bring out with such instruments as the chisel and plane, also influences his verdict as to the quality of the timber. Some varieties of the Scotch Pine, for instance, are so resinous that the tools clog and refuse to work up a fine surface, whereas the beautiful silky lustrous surface of properly planed White Deal (Spruce) is well known to every joiner as easy "to work."

Similar considerations affect the cabinet-maker, etc., who wants a good polishing surface; and he knows that not every smooth wood-surface will take stains or polish —and the remark applies to painting. The turner and the carver are also critical as to the hardness, smoothness, ease of working, etc., of the woods they use. It is also important to these, and others who use wood, whether the timber consists chiefly of heart-wood or of sap-wood: the latter is usually darker, harder, and heavier, but more durable and closer in texture. Considerations of colour also affect the question, and so do those of the power to hold nails.

Some woods contain so much tannic and other acids that the iron of the nails becomes corroded—by chemical action between the metal and the acids—and the nails soon drop out; other woods are difficult to nail, because they split so readily as the point is hammered in; others, again, are apt to warp and twist, and so prize

out the nails. This brings us to the question of "seasoning."

Many woods, if they once become air-dry—*i.e.* deprived of all the water that the air can take up from them at ordinary temperatures—alter very little in volume or shape in the ordinary course of events; that is to say, they do not shrink or swell beyond certain limits which can be tolerated in practice. As a matter of fact no wood exists that does not alter its dimensions as the temperature and hygrometric conditions of the atmosphere vary; and all undergo such changes in volume more in directions across the longitudinal axis of the wood than in those which coincide with that axis. "Seasoning" is also necessary because wood is apt to undergo certain deteriorations of very serious nature, unless the excess of moisture is got rid of. Consequently the joiner, cabinet-maker, etc., will assure himself of the fact that wood has been properly seasoned before he employs it for specific purposes.

4. BY THE CHEMIST.

Let us now inquire what the chemist has to say to our piece of wood.

By means of those two busy handmaids of his—the balance and the fire—we may be sure he can give us some information; though there may be room for disappointment at some of his results, and we stand aghast at the wreck of our object which remains, after he has dissipated its elements by his searching analysis.

We may assume that he will take a somewhat small piece of the wood, and will weigh it accurately in its fresh condition; this piece, having a certain size or

volume—*i.e.* occupying a definite portion of space—will weigh so much.

He will then dry the piece of wood, driving off its moisture (water) at a known temperature, and then again weigh it; here he will pause to note that the weight has diminished considerably—so much water, by weight, has been driven off as vapour, and can be condensed and compared with his first results.

He will also note that the dried piece of wood has diminished in volume considerably; in other words, the wood not only loses weight, but it also shrinks as the water is expelled.

He will find that the amount of water which can be thus driven off by merely *drying* the wood, and not charring or burning it, varies according to the kind of wood examined, the age of the tree which yielded it, the season at which the tree was felled, and the part of the stem from which his specimen was selected, and some other circumstances; it will probably amount to from about 18 per cent. to about 52 per cent. of the original weight before drying — say nearly 40 per cent. as an average number. But he will also find that this process of drying takes place in two stages, as it were. Most of the water comes off easily as the temperature rises above that of a hot summer day, or that of a busy kitchen where the stoves are in full working order—say 25° to 30° C.; but there is a smaller proportion of the water which is held very tenaciously in the wood, and cannot be easily driven off until the temperature ascends to perilously near the scorching point, and which must therefore be expelled by keeping the wood at a temperature somewhat above that of boiling water—say 110° C.—for several hours.

The first lot of easily dissipated water was merely

the water of the "sap," as it is called, held by capillarity in the visible cavities of the wood; but the second lot of water was present in the substance of the walls of those cavities, not as movable liquid water, but as what we know as "imbibed" water, and it was held fast between the structural units of those walls by molecular forces of another category.

Having determined that the piece of wood contained (in whatever form) so much water, the chemist would then proceed to analyse the solid, dry portion, of known weight, which remains.

This he would do by burning it under conditions which he would be able to control. Here, again, he could advance in stages. If he chose, he might first simply raise the temperature, gradually, but far beyond the drying points already referred to, and so distil off as much as could be thus got rid of; he would then examine the products, and would find some curious and interesting results.

Put shortly, about one-half of the substance of the dry wood will be eventually distilled off in the form of gases and vapours, while the other half will remain behind in a solid form.

The gases which escape will consist of Carbon dioxide, carbonic oxide, Marsh-gas, and certain other gaseous compounds of the elements Carbon and Hydrogen.

The more liquid bodies will contain certain compounds of Carbon, with Hydrogen, or with that element and Oxygen, of the nature of Alcohol, Vinegar, and such like substances, Benzol, Xylol, Creosote, and a number of other queer compounds, as well as Ammonia. Moreover, many of these substances will be mixed in a brown or black viscid mess, which is in fact "*tar.*"

Now it is interesting in the first place to notice that many of these substances can be obtained from the products of the rotting, or decomposition of wood, such as goes on in bogs and in the soil; and, in the second, that it is just these bodies which we obtain when *coal* is heated—and we know that coal is practically nothing but wood long bottled up in the earth.

The other moiety of our piece of wood will be found in the form of a much shrunken, but very perfect model of the original specimen, and black in colour: in fact, as a piece of charcoal. It is very interesting to notice that it may show all the essential structural peculiarities of the wood so distinctly, that it is even possible to recognise the species of wood by means of the microscope.

These facts gain in importance when you learn that it is frequently not difficult to make out the characters of fossil woods, and I have had opportunities of satisfying myself that pieces of various species of timber, buried for ages in the earth, show sufficient of their structure, not only to enable one to determine what tree yielded them, but even to show the marks of injury done to them by parasitic fungi, as well as the parasites themselves in their interior. I have also had occasion to examine pieces of charcoal from the remains of an old Roman funeral-pyre, or other fire, the structure of which was quite recognisable. In all these cases the black "carbonised" wood invites comparison with what we know of coal—which is, in principle, indeed nothing else.

The lump of charcoal, representing about half the weight of the dry wood, will be found to consist almost entirely of carbon: I say *almost* entirely, because a small proportion of it will be found to be a mixture of several mineral substances or salts, comprising what is known

as the "ash" of the wood. If, now, the chemist chooses to proceed to extremes, he may raise the temperature still higher, and allow the carbon to burn off in presence of oxygen: in doing this he only completes what we should do if we had burnt the piece of wood in an open fire—excepting, of course, that he *controls* every step in his experiments, and catches and weighs all the products, instead of letting them escape anyhow.

At the end of his complete combustion, then, the chemist finds a minute remnant, weighing only perhaps one per cent. of the weight of the original piece of wood, and looking like a white or grey fine powdery mass, exactly comparable to the ash of a cigar.

In this ash—the actual quantity of which, like the charcoal and other substances referred to above, will depend on the species of wood, the part of the stem analysed, its age, the soil on which it was grown, and the time of the year at which the specimen was collected —the chemist will ultimately discover salts of lime, potash, and magnesia, with phosphorus and sulphur, and possibly traces of one or two other elements, such as soda, iron, silica, and manganese. The results of the destructive analysis, therefore, may be summed up as follows: The piece of wood consisted of

1. Water	about 40 per cent.
2. "Wood"	,, 60 ,,

as compared with the original weight of the fresh, non-shrunken specimen.

3. The dry wood was composed of:

(*a*). Combustible constituents, such as:

Carbon	nearly 50 per cent.
Hydrogen	,, 06 ,,
Oxygen	,, 44 ,,
Nitrogen	,, 01 ,,

And β. Incombustible constituents, or "ash," comprising salts of lime, potash, and a few other elements, forming in all only something like from one to two per cent. of the total weight of the piece of wood.

But it is evident that such analyses as the above would throw little light on the question, in what form are these chemical elements and compounds present in the intact wood? And I shall have to pass over any reference to the methods by which the chemist would proceed in his further examination of the piece of wood, and content myself with the following brief summary.

Mention has already been made as to the water which is expelled on drying, and we have seen that nearly 50 per cent. by weight of the dry wood was carbon, chiefly in the form of a charcoal skeleton of the structure. Before the application of the intense heat of his combustion apparatus, however, the chemist would find that this structural part was composed of peculiar substances known as cellulose and lignin, both of which consist of carbon, hydrogen, and oxygen, combined in different proportions; the destruction of these substances it is which yields the greater part of the carbon compounds referred to above.

Careful examination would also show that starch is present in our piece of wood, and that in quantities which vary greatly according to the season and the age of the wood; in the winter the percentage weight of starch would be considerable, whereas in summer there would be very little.

5. BY THE PHYSICIST.

Examined as a physical object, and by means of the methods devised for measuring and weighing accurately,

the physicist will surely have something to tell us about our piece of wood.

In the first place he will classify it among porous bodies, and his attempts to investigate its properties from his own points of view will help us to throw some light on several points of interest.

The physicist will also, no doubt, investigate the specific gravity, the swelling and absorptive properties, and the capillary phenomena exhibited by the piece of wood, as well as its capacity for conducting sound, heat, and electricity.

First as to the specific gravity. This is a much less simple matter than is immediately apparent at first sight. The question arises, are we to regard the specific gravity as ascertained by comparing the weight of a given volume of our piece of wood—which we have seen contains considerable quantities of water and air—forthwith, and in the fresh state; or are we to first dry the wood, by driving off all the water, at 110° C. or so; or should we adopt some other method?

Obviously, no trustworthy results can be got by the first method; for the quantities of air and water in a piece of fresh wood not only vary according to the time of year, the part of the stem it is taken from, etc., etc., but it is almost impossible to measure accurately a body which is changing its volume so rapidly as a piece of fresh wood does when once exposed to the air.

The second plan would be to thoroughly dry a large piece of the wood, and then cut a portion which could be measured, and compare its weight with that of an equal volume of water. But it is obvious that here, again, what we really get is the specific gravity of the wood *plus* imprisoned air, for the atmosphere drives air in to replace the water expelled on heating; and the

quantity of air thus driven in varies according to the cubic capacities of the spaces in the wood, and to the temperature, etc., and these spaces differ very largely in different pieces of wood, even from the same tree. Consequently, here again we get values which are not constant but variable.

Now let us see how it is possible to avoid these objections, and obtain the real specific gravity of the wood itself. Strictly considered, this can only be done by anticipating some knowledge of the structure of the piece of wood, and it is only fair to point out that the method was devised by a botanist, who combined his knowledge of the anatomy and physiology of the wood, with that of physical methods.

The piece of wood must be so cut that all the tubular cavities in it are opened, and it is then boiled for several hours in some dense medium, such as a solution of some stable mineral salt—say calcic nitrate, or a zinc salt—until all the water and air in its cavities are displaced by the medium.

It is then found that the soaked piece of wood floats at any level in a salt-solution the density of which is 1·56, compared with pure water as unity. In other words, the specific gravity of the wood itself, apart from air and water imprisoned in it, is 1·56, if we call that of water 1, and the striking result is obtained that our piece of wood is itself really heavier than—more than half as heavy again as—an equal volume of water.

Obviously, then, the chief reason why wood floats on water is because it is buoyed up by the air in it; and this also explains why any piece of wood becomes "water-logged," and sinks eventually, if it remains long enough in a river, pond, etc. It also explains why some woods cannot be floated down rivers—the air

cavities are too small, or few, or both, in comparison with the solid matter; and why dry wood floats better than freshly cut, "green" or wet wood—there is more air and less water in the former.

Although the so-called specific gravity of fresh, or of dried wood, is so misleading a value, as usually quoted, nevertheless it is possible to obtain some information of a very interesting nature if we carefully compare a sufficiently large number of determinations.

For instance, by determining the average specific gravity of a number of pieces of the same wood when fresh cut, and then repeating the process after the pieces are seasoned, we obtain at least an insight into the quantity of liquid water which the fresh wood contained. If we add determinations of the specific gravity of the same wood thoroughly dried, at 110° C., we can form some ideas of the distribution of the water in each piece. Of course corrections have to be made for the shrinkage of the pieces, and an ingenious but simple instrument, called a *xylometer* or wood-measurer, has been invented for the purpose of such investigations.

Botanists have taken some trouble to have such measurements carefully carried out, and often repeated, since a good deal depended on a knowledge of the distribution of the water and the air (or other gases) in wood from various trees, and from different parts of the same tree.

Thus, if the weight of a given piece of wood, measuring 100 cubic centimeters when fresh from the tree, is found to be 85 grams, and that of the same piece, perfectly dry, is 35 grams, then we know that the fresh piece of wood contained altogether 50 grams of water, which we expelled as vapour.

The weight of the solid dry wood being 35 grams,

we can—since we know its true specific gravity is 1·56 —determine the cubic contents of the solid substance: it is $\frac{35}{1{\cdot}56} = 22{\cdot}43$ cubic centimeters. That is to say, of the 100 cubic centimeters total volume of the fresh piece of wood, 22·43 cubic centimeters were solid substance, and therefore 77·57 cubic centimeters were cavities, and in these cavities (if we assume that no other spaces exist) the 50 grams—*i.e.* 50 cubic centimeters—of water were distributed.

This would imply that $77{\cdot}57 - 50\ (= 27{\cdot}57)$ cubic centimeters were occupied with air or other gases.

But the assumption that all the water must be contained in the cavities is found to be erroneous, for it turns out that a portion of it is taken up into the *solid substance* of the wood itself, and is there held with peculiar tenacity. It is this imbibed water, in fact which it is so difficult to get rid of, even at high temperatures, and which never is expelled in the ordinary process of drying, or "seasoning," wood. It is measured by the following method. A piece of the wood is dried thoroughly at 110° C., and its volume and weight determined; a thin transverse slice is selected, because it cracks radially as it dries. The thoroughly dried, cracked slice of wood is now hung in a moist atmosphere, kept at a suitable temperature, for several days. Here it absorbs and condenses some of the water, and the crack closes up tight. When it is found that no more water is thus absorbed, the piece of wood is again carefully weighed and measured and examined, and it is found that although there is no liquid water in the cavities, the increase in weight is considerable.

Now, since the volume of the wood-substance was known—by dividing the dry weight by the specific gravity 1·56—it is possible to determine the relations

between this volume and that of the hygroscopically absorbed water. Numerous experiments have shown that this imbibed water ranges from 50 to 90 per cent. of the volume of the solid wood-substance, according to the species and some other circumstances. In the case selected we will take it at 50 per cent.—*i.e.* half the volume of the solid wood-substance.

Returning to our example, then, we find that our piece of fresh wood, the volume of which was 100 cubic centimeters, and the weight 85 grams, contained 50 grams of water altogether, and 35 grams of solid substance.

The cubic contents of this solid substance measured 22·43 cubic centimeters, and would contain half that volume—*i.e.* 11·215 cubic centimeters—of imbibed water, making 33·645 cubic centimeters in all.

The remainder of the cubic contents refers to the cavities: it would be 66·355 cubic centimeters.

Now there were 50 cubic centimeters of water altogether in our 100 cubic centimeters of fresh wood, and we have accounted for the distribution of 11·215 cubic centimeters of its water. Obviously, the difference, namely 38·785 cubic centimeters of water, was contained in the cavities, and as these measured 66·355 cubic centimeters, the remainder—*i.e.* 27·57 cubic centimeters—was gaseous matter, and as a matter of fact we know that it was chiefly air-bubbles.

This will suffice to show you how very complex a structure our piece of wood is, and to convince you that the physicist is in error if he regards it merely as a "porous body," for it is obviously much more than what is implied by that term.

As we shall see presently, the piece of wood consists essentially of bundles of tubes, and, consequently, it

offers certain problems in capillary phenomena. Recent researches have shown that these problems are complicated by the behaviour of the air-bubbles above referred to, and which are entangled between the water-columns in the various tubes, of different calibre, length, and substance, of which the wood is constructed.

6. BY THE BOTANIST, FORESTER, ETC.

The scientific botanist sees in any piece of wood a complex structure cut up into tubes of various kinds, and differing in length, diameter, and the thickness of their walls.

These tubes may be empty—*i.e.* contain only air—or more or less filled with certain substances of the nature of starch, sugars, resins, etc. They may also be grouped in an immense variety of combinations, and the directions of their longer axes may be either coincident with that of the long axis of the stem or across it.

The closer microscopic examination of these tubular elements of the wood discloses various irregularities or markings on the walls of these tubes, and long experience of many such examinations convinces him that certain types of such markings constantly recur in different timbers. The botanist is consequently enabled to classify or group the various tubular elements into a few classes, or types, to which he gives technical names.

The botanist is also concerned with the origin, or development, of these elements, and finds that they arise in all woods from the same primary element, and follow the same course of development in each and every case.

Such studies have led him further, however, and he has had to frame conceptions of the ultimate structure

of the walls of these tubes, or elements, the result being that a piece of wood turns out to have a complexity of structure far beyond anything that was supposed to exist by the older observers.

But structure suggests function. When we see a piece of machinery, we are not satisfied with knowing how its parts are put together, and what these parts are composed of; we, almost instinctively, ask, how do the parts work, and what duties do they perform, severally and collectively. So with the botanist—not content with knowing the structure and origin of the parts, or tubes, themselves, or with observing how they are grouped or arranged, he at once proceeds to inquire what they do.

Putting the results of such investigations quite generally, it is found that all wood, whether in small quantity as in herbaceous plants, or in large quantity as in timber, may be broken up into long or short, open or closed, wide or narrow, thick or thin-walled tubular elements.

Some of these are not much longer than broad, and may be compared to boxes of parallelopiped or shortly prismatic shape, and are termed, generally, *cells*. The individual differences between the cells of one wood and another, or the wood from one part of a plant and that from another, chiefly depend on their number and states of aggregation—in layers, clumps, long tracts, etc.—on the nature of their contents, including colour—on the thickness of their walls, as well as the chemical substances (including pigments) to be extracted therefrom—and on the form and size, etc., of the markings on these walls, due principally to irregular or regular difference of thickness.

Others of these elements—to pass to the extreme

forms—are long, open, more or less cylindrical pipes or tubes, termed *vessels*, which run through long distances, especially vertically, without our being able to detect any stoppage or closure of their calibre. The differences between the various vessels depend on much the same principles as those between cells, but since the contents are usually only air (in ripe timber), and the markings on their walls are usually very characteristic and prominent, it is the latter especially which aid us in distinguishing them, and *pitted*, *annular*, *spiral*, and *scalariform* vessels are names of the commonest types.

Leaving these two extreme examples of element, there is found in all wood a remarkable intermediate type, which consists of prismatic closed tubes, several times longer than wide, and containing living contents at least when young.

This type of wood-element is the most important of all, for it is the fundamental one from which all the rest are derived.

In its youngest condition—in real timber—it is known as a *cambium-cell*, and we must here neglect the fact that it was itself derived from a more primitive condition. When its walls have become thickened and its living contents have become exhausted, it passes over into one of two structures. It either becomes a *fibre* or a peculiar prismatic element termed a *tracheid*.

Now, since the *cells* of the wood may be regarded simply as one of these prismatic elements *cut up into shorter closed prisms*, or boxes, and since the *vessels* are merely pipes formed by the intercommunication of a longitudinal series of these prisms, *their joined ends being broken through*—in a certain sense very much as a water-pipe might be formed from a series of elongated

casks, if we suppose them put end to end and the partitions broken through—it is evident that the prismatic cambium-cell is the primitive form of wood-element.

Put in this very general way, then, we may say that all wood whatever is formed of elements of the above types derived from the primitive prismatic cambium-cell or its homologue, and in all true timber—the masses of wood of Coniferous and Dicotyledonous trees—the cambium-cells are grouped into a cambium *layer*, or *cylinder*, which appears as a ring (the cambium-ring) on a transverse section of the stem. In the Monocotyledons (Palms and Bamboos for instance) and in the Tree-ferns, and in a few other rare instances, however, there is no such cylinder, and although the general principle above stated is still true, there are certain peculiarities in detail concerning these false timbers, the discussion of which belongs to botanical works.

True timber is yielded only by Conifers and Dicotyledons, and in all these cases we find a *pith*, *medullary rays*, and *cambium*, as well as the mass of *wood* proper. But it by no means follows that all the derived elements—cells, vessels, tracheids, and fibres—occur in any particular wood, and it is largely due to differences of this order that various woods are so different in structure and quality.

All woods—whether forming true timber or not—possess at least a few spiral vessels in the earliest stages; but in Pines, Firs, Cedars, Larches, and a few Dicotyledons, they are only discoverable with the aid of the microscope close to the pith, where they were formed with the first wood, and *no true vessels of any kind occur in the main mass of wood.* In most Dicotyledons, however, and in the Palms, Bamboos, and Tree-ferns,

various other vessels occur in the wood, and their number, mode of grouping, width of calibre, and the thickness and markings of their walls afford valuable characters in recognising timbers.

Thus the vessels are much more numerous in the Willows, Poplars, Lime, etc., than on an equal area of Ash, Oak, or Walnut. They differ much in size, also, being large enough to see without a lens in Vines, *Aristolochia*, and even in Oaks and Palms, etc., whereas they are so small in Box, Willows, Birch, etc., that the beginner is apt to confound these woods with that of Conifers, which have no vessels.

Then, again, many woods examined in transverse section have the vessels grouped in clusters, beautifully seen in the Buckthorn and Elms, whereas others—*e.g.* Beech—have them equably distributed. Moreover, the grouping may be different in different parts of the transverse section, large vessels in one region and smaller ones elsewhere, *e.g.* Oak, Ash, etc., and many other peculiarities are noticeable, especially in the microscopic characters of the vessels themselves.

Cells always occur in the medullary rays, but they are often either very sparse or absent in the wood proper, whereas in some woods—*e.g.* *Ailanthus*, *Erythrina*, *Bombax*, etc.—they are so abundant as to give the timber a peculiarly soft and pith-like character. In many timbers, also, these cells are arranged in a definite manner, giving contrast-markings on the transverse sections as seen by the unaided eye: such are well seen in species of *Ficus*, and many Leguminosæ. Possibly no wood is totally devoid of cells, but in very many they are confined to the neighbourhood of the vessels and medullary rays, and are so few in number that their presence is doubtful.

Fibres are characteristic of dense and tough woods, but there are many timbers which show no traces of them. Thus, true fibres do not occur in Pines, Firs, Larch, Cedar, Pear, Hawthorn, and a few others; whereas they abound in such woods as Oak, Ash, Elm, Chestnut, etc. In most hard woods the fibres are scattered among other elements, often in characteristic groups or strands, and it is at present impossible to make any generalisation as to the relation between the mechanical properties of wood and the distribution of the fibres in it; it is clear, however, that much depends on the length of the fibres, and on the degree of thickening and hardening undergone by their walls.

Tracheids occur in nearly all timbers, and in some cases—*e.g.* Pines, Firs, etc.—the wood is composed entirely of these elements. Tracheids are confounded with fibres by nearly all observers except the more modern ones, and the distinctions between them are not always easy to make out. Mechanically they affect the wood much as do the fibres, imparting to it the properties of hardness, toughness, and heaviness, in proportion to their number and length, and the density and thickness of their walls.

It is obvious that many characters useful in distinguishing timbers can be obtained from the points of structure referred to, though only in the hands of skilled observers. But these latter also make use of many other peculiarities of structure in woods for purposes of identification.

Oak and Chestnut can be distinguished by the peculiarities of their medullary rays, and Alder and Birch likewise, and the breadth, depth, and other peculiarities of medullary rays are widely employed for such purposes.

Annual rings also are very useful distinguishing features in most woods. There are none at all in Palms, Bamboos, Tree-ferns, etc.; and they are indistinguishable in many exotic timbers—*e.g.* many Indian Oaks and other timbers—while they differ in course, breadth, and sharpness in various ways in other woods.

Heart-wood is formed by many trees, and is quite different in colour, hardness, density, etc., from their sap-wood; but there are others which show no traces of it to the observation. Some trees form it early, as the Oak, others late, as the Ash, and great differences occur in these respects.

There are numerous other points of structure, most of them technical in character and not suited for discussion here, that help the expert to determine the nature of a piece of wood. The resin-canals of the Pines, Larches, and *Anacardiaceæ*; the so-called "pith-flecks" of many Birches, Alders, Hawthorns, Poplars, etc.; the peculiar contents of the cells in Birch, Alder, Mountain Ash, Pear, Ebony, etc.; or of the vessels in Teak, Robinia, and others, are all instances. To these may be added the peculiarities of weight (per cubic unit), grain, hardness, toughness, and even odour—*e.g.* Teak and Cedar.

The botanist is also concerned with the functions of timber. Broadly speaking, these are, support and flexibility—the very mechanical purposes to which we apply timber apart from the tree—due principally to the fibres and tracheids; the conduction of water and air—properties especially attributable to the vessels, and to which regard must be had in all cases of flotation, etc.; and the storage of organic materials, the substances we have to take into account, owing to their putrescible nature, in preserving and seasoning timber, and to

which the burning properties of wood are due. These organic and readily combustible constituents of timber affect its durability in many ways; not only are they apt to oxidise in the air, but it is these bodies which are consumed by various insects and fungi and other organisms which destroy the timber.

Clearly, therefore, the points of view from which the forest botanist examines and reports upon our piece of wood, affect the arts in very many ways. Not only so. The discovery that wood is a complex structure of tubular elements, the walls of which are capable o absorbing or giving off water, entirely modifies all the older views as to the "porosity" of timber. We must *not* compare a piece of wood to a piece of chalk, or brick, or other capillary absorbent; the water which passes into the tubes (vessels, tracheids, cells, etc.) must be distinguished carefully from the water absorbed, and held much faster, in the porous walls of these elements. And similarly with regard to air. This not only concerns all views as to the physical properties of wood, but it shows that any mere weighing of equal volumes of two different timbers by no means gives accurate results as to their specific gravities, for instance. You might as well take two chambered boxes of equal size, filled with different substances, and imagine that their comparative weights gave you a constant of value, as compare directly the weights of a cubic foot of two different kinds of timber without regard to their structure and other peculiarities.

Moreover, the study of timber from these points of view profoundly affects all experiments on its infiltration or impregnation with various poisonous preservative substances. The difficulty of forcing solutions of phenol, cupric sulphate, mercury salts, etc., into wood, by the

highest pressures, becomes intelligible only when the real differences between wood and ordinary "porous bodies" are understood.

That much of our empirical knowledge as to the strains to which wood may be subjected, as to the kind of wood-work (carving, carpentry, turning, etc.) it is fitted for, its burning properties, etc., will be improved as these things are more understood cannot be doubted. Finally, the experience of foresters and botanists is showing that these and other qualities of wood are profoundly affected by the conditions under which the timber is grown, and thus another wide horizon is opened up for further exploration.*

* For further particulars the reader should consult "Timber and Some of its Diseases" (Macmillan & Co.), and "The Oak" (Kegan Paul & Co.).

CHAPTER I.

ON THE GROWTH AND STRUCTURE OF TREES.

THE stems of Dicotyledonous and Coniferous* trees may be described as of comparatively uniform structure and mode of increase, and are usually very firm, yielding the most solid and best description of timber, their solidity and strength fitting them admirably for use in carpentry, and for many domestic purposes.

The most common form of stem is the cylindrical, but it is occasionally found grooved or fluted, and not unfrequently flattened, approximating to an oval; the cylindrical form being, for most purposes, the best for conversion into beams, joists, boards, etc.

Botanists speak of the stem as the "ascending axis" of a tree, from its taking an upward direction and giving off branches. In the Elm, these branches take an oblique upward direction; in the Birch, they are also oblique, slightly pendulous, and flexible; those of the

* Dicotyledons and Conifers are trees, etc., which augment their woody structures by periodic additions to the outside of that which is first formed; as long, therefore, as they grow a new layer of wood is normally added to the outside of the previous growth. The Monocotyledons—*i.e.* Palms, etc., etc.—differ from the above, in having their woody structures formed in successive strands, so isolated in softer cellular material as to be almost useless for timber. To a certain extent the stems of Tree-ferns resemble the latter in this particular.

Willow are somewhat oblique, with the lateral branchlets pendulous and drooping in graceful curves; in the Lombardy Poplar and Cypress they are nearly erect; the Oak, in open and exposed situations, takes a wide-spreading form, its branches assuming every imaginable curve; while in the Cedar they are nearly at a right angle.

The stem is constructed upon the principle of a cone, and consists of a series of perfected layers designated heart-wood, or duramen, while outside these are some young layers that are imperfect, and which are known as the sap-wood, or alburnum; the exterior is composed of a series of outer layers commonly termed the bark. The main portion of the stem is broadest at the base, and somewhat bell-shaped near the root, but gradually diminishes upwards to the part where the first branches are thrown out, and from this point there is again a still further diminution, until it is finally lost in the extremity of the branchlets.

The central part of the stem, namely, the pith, is composed of cellular tissue, the cells being very numerous and varying considerably in size, but generally diminishing towards the outer edge. The pith is relatively large and full of fluid in the young plant, but does not increase in bulk as the tree grows older; on the contrary, it appears rather to diminish than otherwise, by the fluid drying out. It retains, however, its place, even in the oldest trees, in the form of a dry mass, often resembling powder, although it is scarcely noticeable in some species on their arrival at maturity.

In the employment of timber in carpentry, due regard must always be had to the position of the pith, since there is an outside and an inside to every board and piece of scantling; and the careful workman is so

well aware of this, that he will study to leave, if possible, in any work of construction, the outer side only exposed. It is, therefore, necessary in every case to look for the pith or centre of the stem, or—if that has been removed by the conversion of the tree—for the innermost, or

FIG. 1.

oldest layer of heart-wood, in the plank or board, as that will be the inside of it. If this precaution is disregarded, the innermost or earlier layers of wood lift and shell out, after exposure for a time, in shreds and strips, the cohesion of the successive layers of wood having been destroyed by the action of the atmosphere. Fig. 1

FIG. 2.

shows the plank properly fixed, with the inner or earlier layers of wood against the beam, in which position they do not so readily separate. Fig. 2 shows the plank improperly fixed, with the outer, or younger layers of wood against the beam, in which position the earlier layers are very liable to lift, or shell out, destroying the evenness

of surface; and when so used in decks, flooring, etc., rendering it dangerous to walk upon.

In the transverse section of a tree will be found a number of lines radiating from the centre and presenting a star-like appearance. These are the medullary rays of the botanists, but are best known to carpenters as the silver grain, or felt (*a*, Fig. 3). This peculiarity of appearance is due to thin plates of compressed cellular tissues, which usually run continuously from the pith to the bark. In some timbers (*e.g.* Oak, Beech, etc.) other series of medullary rays are found, overlapping or scarfing by, but not touching, the larger rays (*b*, Fig. 3). If, therefore, we carefully examine the smooth surface of a transverse section of the stems of most trees, we can generally trace these thin plates or rays. They can be seen to great advantage in the Beech, and, more or less, in all the varieties of Oak; but they are far less distinct in the Lime, Yew, and Chestnut, and in the Firs and Pines they cannot be obviously traced without lenses, although botanists know them to be present. No timber trees are devoid of medullary rays, and their peculiarities of colour, size, number, etc., are of great value in determining different timbers. Thus Oak and Beech, etc., have two sizes of medullary rays, a few

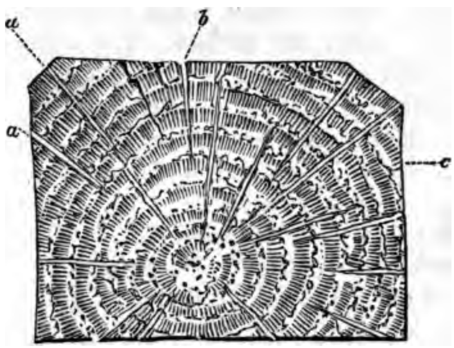

FIG. 3.

very broad ones and numerous very narrow ones; Chestnut, on the other hand, is easily distinguished from Oak by having no broad rays. While the medullary rays of the Willows, Poplars, and Hawthorn, etc., are colourless, those of the Elm, Birch, Alder, Beech, etc., are pigmented.*

Before converting or employing most kinds of woods, particularly in dealing with unseasoned timber, it will be necessary, for many purposes in carpentry, to regard this arrangement of medullary rays, to ensure that the work shall remain, when finished, free from warp or twist upon the surface. The timber should be cut as nearly as possible in the direction of these rays, the shrinkage in seasoning being, for the most part, angular to them. Workmen in general, and modellers in wood in particular, endeavour to embrace the greatest length of medullary figure in their work to guard against warping, well knowing that if they do so it will stand satisfactorily the test of time and wear. Others, who are engaged in the cleaving of posts, rails, or palings for park and other fences, know that they can only successfully do this by rending the piece in the direction of these rays. It is by a careful study of this that we obtain our best and most beautifully figured wainscot from the slow-growing Oaks found in the North of Europe, Austria, Asia Minor, and in some districts of North America.

By the mechanism of these medullary rays in intimate connection with the annual layers, and chiefly in the newly-formed wood, a means is afforded for the ascent of water, containing traces of dissolved mineral salts, such as potash, lime, common salt, etc., and gases, such

* For other characters of the medullary rays see "Timber and Some of its Diseases" (Macmillan & Co., 1890).

as oxygen, etc., obtained from the rain-water in the soil and taken up by the root. This "sap" is found to move upwards every spring, and continues for a time to flow through the tubular and pipe-like structures composing the wood of the tree until it reaches the leaves; here it is distributed to the cells containing the green chlorophyll, and gives up to them its minerals. These living leaf-cells, properly supplied with water and mineral salts, and exposed to the sunlight, are able to manufacture from the carbon dioxide of the air, certain organic compounds which require very little chemical change to become wood-substance. These compounds are then carried down from the leaves into the stem, and pass, by various routes—*e.g.* the medullary rays, the inner tissues lining the bark, etc.—to wherever they are needed by the growing parts of the tree.

Of these growing and living parts of the stem none is so important to us as the cambium, a very thin and delicate layer of active cells, easily found in immediate contact with the outside of the sap-wood, and often regarded by the uninitiated as a slimy substance between the wood and the inner bark. It is not a mere substance, however, but a definite, though extremely tenuous, mantle of living and growing cells, fed by the substances dissolved in the sap handed on to it from the leaves.

This cambium, if properly supplied with food-materials, adds new layers of wood on to the *outside* of the wood already formed, and new layers of other living tissues to the *inside* of the structures found beneath the bark, which structures may be collectively termed the cortex.

The stem is thus enlarged periodically by a new layer on the outside of the alburnum, and by the

addition of a new layer on the inside of the cortex, the cambium itself remaining between, and exerting its activity at definite periods, usually in the summer in our climate. Thus the bark and cortex of trees is expansive in character, and it is owing to differences connected with this that we find such differences observable on the surface, which varies from great smoothness, as in the Beech, to extreme ruggedness in the Chestnut, and to strips and flakes in some other kinds.*

It is around the pith that the first year's growth of wood is formed, and upon this the whole structure of the stem is, so to speak, raised. The several concentric rings or layers which surround, and are, as it were, moulded upon it to form the cone, are generally well formed and uniform in thickness, seldom varying; when they do the pith is excentrically placed, or deviates somewhat from the centre. Whenever this is the case, the thinner layers will be found upon the side having the smallest semi-diameter; while on the reverse side, owing to the annual supply of ligneous matter having been drawn in that direction by various influences, they are found to be thicker, but are often less dense in texture.

The yearly growth or increment is thus defined by concentric circles outside the medullary sheath† (*c*, Fig. 3). These are generally clear to common observation in a transverse section of a stem, the outer portion of each being of a firm and dense texture, while the inner part is perceptibly vascular and more or less porous; the quality of the wood, and its fitness for architectural or

* For further information as regards the cambium, its structure and growth, see "Timber and Some of its Diseases."

† The "medullary sheath" is the first formed cylindrical layer of wood.

engineering purposes, depends, to a great extent, upon the degree of firmness and solidity of the annual layers. These layers are all very plainly marked in the Oak and Fir, and in most European woods; but in the Maple and Lime, and in some others, they are less obvious, while in many trees of tropical growth they are so indistinct that it is impossible to trace them.

The woody layers, when first formed, are full of sap, but they change and gradually become solidified by the thickening and drying of the wood-cell walls of each

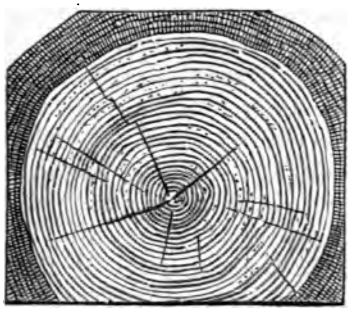

FIG. 4.

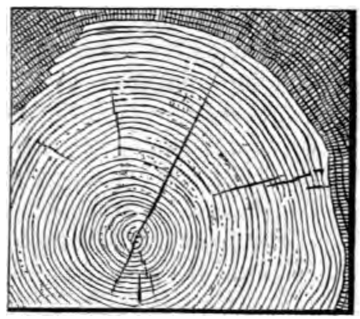

FIG. 5.

subsequent layer, and their infiltration with various preservative and other materials; and as each zone is moulded upon one of the previous year's growth by the action of the continuous cambium, it must, by cohesion, be amalgamated with it. The perfecting of the concentric layers is, however, a very gradual process, and the time necessary to convert a new layer of sapwood into heart-wood (which alone represents the serviceable timber in most trees) varies from about one year to thirty years or even more. It seems, as a rule, from evidence to be shown later on in Table I., that

Oak trees which form their wood most rapidly under ordinary conditions of growth are the best in quality. In the Firs and Pines and Conifers generally the converse is usually true.

Under ordinary conditions of growth, and with most trees, the conversion or change of the alburnum into duramen takes place with great regularity (Fig. 4); but to this rule there are exceptions in every species, a variety of influences, such as temperature, aspect, soil, and others less understood, apparently bearing upon and tending to disturb this regularity. It is, indeed, often found that outside the completed circles of duramen, portions of the circumference of several successive layers of alburnum (Fig. 5) have already been changed into heart-wood, while the rest remain to be indurated in the ordinary course; the perfected segments generally occurring earlier on the south side of trees of the Northern Hemisphere, and on the north side of those of the Southern Hemisphere.

This is, perhaps, only to be accounted for by the supposition that, being exposed to the most powerful rays of the sun, especially during the summer months, the indurating elements of the sap tend more that particular side; while, on the reverse side, the action is much slower, owing to the partially exhausted state of the juices and the deadening effects of cold.

Such indurations of portions of the layers occur more frequently in the Firs and Pines than in the wood of trees of harder and more compact texture. In Dantzic Fir, for example, I have noticed parts of twenty or more concentric rings changed from alburnum into duramen, or heart-wood, while the remaining portions of the circles retained their sap-like or alburnum character, and greater or less deviations in this respect are fre-

quently met with in other species. It may be that these can only be accounted for by the exceptional influences before mentioned, for it seems quite possible that, whenever a tree is suddenly thrown open and exposed by the clearing away of others from its vicinity, the hardening process will go on with unusual rapidity.

In such Firs and Pines as have been sheltered in the depths of a forest, we do not find the wood of this variable character, as the perfecting of the duramen takes place then with much greater regularity and uniformity, if somewhat less rapidly, than in more exposed situations.

This peculiarity is more strikingly exemplified in the Firs and Pines, and occurs with greater frequency in trees of this kind than in any others. Accidental circumstances no doubt affect the sap-wood of many other kinds to a greater or less degree; but in trees of a close texture the induration is generally found to affect the whole circumference of a layer rather than several distinct portions of it.

The proportion of sap-wood, or alburnum, to heart-wood, or duramen, in trees in which it occurs, is excessive in the young, but decreases rapidly as they advance in age, the difference being in some measure attributable to the fact that, as the circumference of the tree increases, the tissues of each successive layer, or annual ring, are spread over a larger surface. The sap-wood is, as a rule, darker in the white-wood class than the heart-wood, whether seasoned or unseasoned, but is paler in colour in most hardwood trees which have had time to season. In some of the white, or softer woods, when fresh cut, the difference is scarcely perceptible; but exposure to the air quickly gives to the outer layers a greenish tinge, due to a species of mould fungi which attack them, and

flourish at the expense of the organic cell-contents. With, I believe, only a few solitary exceptions, great care is taken to remove all sap-wood from the scantlings under conversion, if they are required for works of an important character.

CHAPTER II.

ON THE GROWTH AND STRUCTURE OF TREES (*Continued*).

MOST writers upon the subject of the growth of timber are agreed in ascribing the hardening of the inner layers of the wood (heart-wood) to the indurating action of certain secretions as they accumulate in the walls and cavities of the fibres and other tissues, and thus far I have treated of the process as carried on solely by this means; but another and a very different set of events bring about the different degrees of hardness often found between one part of the annual ring and another. It will be remembered that each year the cambium, developed between the last-formed ring of wood and the bark, exerts its specific activity and forms a new layer. This layer, as it is completed, and its elements become firmer by the thickening of their walls, appears to exert a double influence upon the tree, inasmuch as it exercises an expansive force upon the bark, thereby causing it gradually to yield, while the resistance it offers, slight though it may be, acts as a compressive force upon the whole of the tree comprised within the circumference of the new layer. By means of this compression parts of the layers are rendered more dense, horny, and compact.

We thus find the woody layers gradually assuming a tapering or conical form (Fig. 6), and elongating themselves year by year, so that a large proportion of those visible at the butt are traceable at the upper part of the stem.

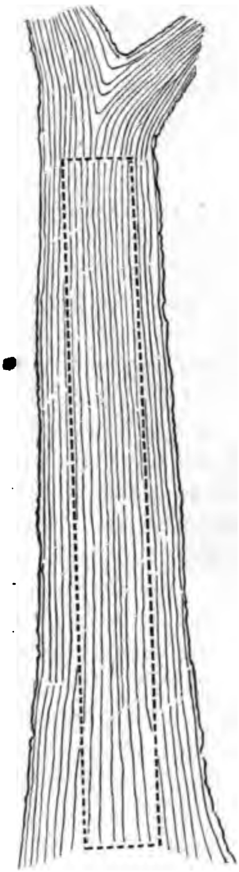

FIG. 6.

It is very generally admitted that, in latitudes having the seasons clearly defined as they are in this country, each circle of lignified wood-tissue is completed in one year, but opinions differ as to this being the case in tropical climates, and there are botanists who consider that as many as three or four layers are formed in those regions in the same period of time. Relying, however, on the generally recognised rule, of one circle or layer for each year's growth, we have a measure and guide for computing the age of a tree at the time of felling it. Of course, this can only be done with trees having clearly defined concentric circles; in the instances exceptional to this, we, of necessity, have to fall back upon historical or traditional records to satisfy our inquiries.

It may be interesting here to note the size and age which some species of trees attain. It has been said that specimens of the "Baobab" of Senegal are more than 5,000 years old, and that some of them have a

girth of 90 feet.* Again, some Cedars that were seen in Lebanon in the sixteenth century were considered to be the remains of the forest from which the timber was drawn to build the temple of Solomon. By tradition, and other reasoning, the age of these Cedars was set down at about 3,000 years. Maundrell mentioned that the largest he measured of this species was about 36 feet in diameter.

Decandolle gives the following list of the ascertained ages of the undermentioned species of trees :—

Elm	335 years.	Lime	1,147 years.
Cypress	350 ,,	Oak . . .	810 to 1,500 ,,
Larch	576 ,,	Yew . .	1,214 to 2,820 ,,
Cedar	800 ,,	Adansonia . . .	5,000 ,,

These figures have, doubtless, been based and computed upon the supposition I have advanced of there being one concentric circle for each year of growth; but, as they do not serve us for any practical purpose, we must look to those trees of moderate dimensions, which attain to maturity in a shorter time, rather than to those I have enumerated, for the timber we may wish to employ for architectural works. The record, however, which these circles afford of the duration of life in trees possesses a value of which we cannot but feel the interest.

I have carefully examined and counted the annual layers of a great many specimens—taking generally an average of ten trees—with the view to show the common and comparative rates of growth, and have tabulated them to afford an opportunity of noticing any variations there may have been in the time required to form the wood in each of the several given diameters

* It is impossible to accept these estimates, however, in the absence of knowledge as to the rate of growth of the tree, and more recent observations throw such grave doubts on them that we may conclude the age of these trees is vastly exaggerated.

of 6, 12, 18 inches, etc. This evidence of the ordinary rate of growth, and the time which it takes to bring the various descriptions of timber trees to maturity, will be of value to us when considered in connection with the properties and characteristics of the timber employed for architectural works.

The number of concentric circles, or woody layers, found in various timber trees, within a radius of 3, 6, 9, 12, 15, 18, 21, and 24 inches, measured from the pith, or centre, are shown in the following table:—

TABLE I.

No.	Description.	Diameter of the Stem. Concentric circles, or woody layers, in								Number of trees examined.	Average number of layers to make one inch at 24 in. diam.
		6 in.	12 in.	18 in.	24 in.	30 in.	36 in.	42 in.	48 in.		
1	Oak, English . .	22	34	51	68	...	...	...	...	10	2·84
2	do. do.* . .	12	20	28	36	44	53	64	76	10	1·50
3	do. do.* . .	13	19	24	30	37	40	44	49	1	1·25
4	do. French . .	18	34	47	60	...	...	...	...	10	2·50
5	do. Roman . .	15	28	43	62	76	...	...	...	10	2·60
6	do. Sicilian . .	24	44	65	87	104	...	...	...	10	3·60
7	do. Neapolitan .	19	37	58	72	86	110	128	...	15	3·00
8	do. Sardinian .	25	45	65	89	...	...	...	...	10	3·70
9	do. Dutch or Rhenish	29	56	81	107	140	...	...	...	6	4·45
10	do. Dantzic .	27	58	87	...	...	...	...	...	6	4·83
11	do. Spanish .	36	81	130	...	...	...	...	...	4	7·20
12	do. Turkish .	...	...	...	...	...	...	...	...	3	12·00
13	do. American White	36	63	89	112	129	...	...	...	10	4·70
14	do, do. (Baltimore)	46	82	137	183	...	...	...	...	10	7·60
15	do. do. (Canadian)	49	105	160	216	...	...	...	...	4	9·00
16	Teak, Burmah (Moulmein)	27	47	71	96	...	...	...	...	10	4·00
17	do. do. (Rangoon)	27	60	87	114	...	...	...	...	5	4·75
18	do. Malabar .	19	40	64	90	...	...	...	...	10	3·75
19	do. Siam . .	28	59	88	118	...	...	...	...	5	4·90
20	Pyengadu (Ironwood), Burmah	...	...	...	...	...	...	...	...	3	†
21	Chow, or Menkabang Penang, Borneo .	...	...	...	...	...	...	...	...	4	3·00

* These were trees of magnificent growth and first quality. † Not clearly traceable.

TABLE I.—*Continued.*

No.	Description.	Diameter of the Stem. Concentric circles, or woody layers, in 6 in.	12 in.	18 in.	24 in.	30 in.	36 in.	42 in.	48 in.	Number of trees examined.	Average number of layers to make one inch at 24 in. diam.
22	Pingow, Borneo	...	...	...	...	...	...	...	...	4	*
23	Kranji, do.	...	...	...	...	...	...	...	...	4	*
24	Kapor, do.	...	...	...	...	...	...	...	...	4	7·00
25	Molave, Philippine Islands	...	...	...	...	...	...	...	...	3	*
26	AfricanOak, Sierra Leone	40	69	94	118	...	...	...	...	10	4·90
27	Greenheart, Demerara	37	63	83	...	...	...	...	...	3	4·60
28	Mora, Trinidad	30	53	76	102	...	...	...	...	6	4·25
29	Carapo, do.	...	...	...	...	...	...	...	...	2	5·00
30	Balata, do.	...	...	...	...	...	...	...	...	2	8·00
31	Sabicu, Cuba	32	57	88	134	...	...	...	...	10	5·60
32	Mahogany, do.	31	55	76	100	..	...	...	...	10	4·20
33	do. Honduras	25	43	60	77	...	...	...	...	10	3·20
34	do. Mexican	17	30	44	59	73	...	...	...	10	2·45
35	Santa Maria	28	59	86	117	...	...	...	...	3	4·87
36	Tewart, Australia	23	45	63	93	...	...	...	...	10	3·90
37	Jarrah, do.	...	...	...	...	...	...	...	...	6	*
38	Iron Bark, do.	...	...	...	...	...	...	...	...	3	4·00
39	Blue Gum, do.	...	...	...	...	...	...	...	...	2	3·30
40	Stringy Bark, do.	...	...	...	...	...	...	...	...	3	*
41	Kari, Western do.	18	37	59	82	108	...	...	...	3	3·41
42	Ash, English	19	35	54	70	...	...	...	...	6	2·90
43	do. American	36	77	116	152	...	...	...	...	4	6·36
44	Beech, English	17	33	50	68	...	...	...	...	6	2·83
45	Elm, do.	21	34	45	57	...	...	...	...	10	2·80
46	do. do.*	10	16	25	36	48	61	82	101	1	1·50
47	do. Canada	80	156	252	...	...	...	...	...	10	14·00
48	Fir, Dantzic	23	49	85	116	...	...	...	...	10	4·82
49	do. Riga	29	60	96	124	...	...	...	...	10	5·20
50	do. Polish	29	55	88	137	...	...	...	...	10	5·70
51	do. Spruce	68	...	...	...	...	...	...	...	6	11·40
52	Pine, Canada Red	16	34	66	123	...	...	...	...	10	5·13
53	do. do. Yellow	28	73	102	125	...	...	...	...	10	5·22
54	do. American Pitch	32	61	98	147	...	...	...	...	10	6·12
55	do. Oregon	17	46	77	104	...	...	...	...	2	4·32
56	do. New Zealand Kauri	53	95	130	161	207	247	...	...	4	6·70
57	Larch, Polish	23	52	90	132	...	...	...	...	7	5·50
58	do. Russian	27	64	108	130	...	...	...	...	10	5·42
59	do. Italian	...	...	...	...	...	...	...	...	...	...
60	Cedar, Honduras	13	22	31	43	58	70	...	...	10	1·95

* See Note (†) on p. 44.

The measurements in the foregoing table were taken at consecutive distances of 3 inches from the pith of trees having well-formed concentric rings, and by doubling this, the diameters of 6, 12, 18, 24, 30, 36 inches, etc., were obtained. There are only two or three of these results that can be compared with the list furnished by Decandolle, but severally they will be found useful for reference; and, later on, I shall have occasion to revert to some of them, when treating of the characteristics of the individual kinds to be noticed in these pages.

The proportion which the width or thickness of each layer at the upper bears to that at the lower extremity of the tree, varies considerably in the several species, the difference being the least marked where there is the greatest length of clear stem. Indeed, as the material which goes to form a branch may be regarded as so much matter diverted from the trunk itself, it follows that in a tree in which the branches occur low down, the stem will taper more than in one which has them only near the top. The diminution in the thickness of the layers will be most apparent in the trees which produce the largest branches, and will be regular or irregular according as the branches are thrown out at regular intervals or otherwise.

It might be supposed that as every layer from the pith, or medulla, to the bark is in a different stage of perfection, the innermost or earliest, being the most matured, would be the strongest; but experience teaches us that this is only true up to a certain period of growth, and that in the majority of cases the maximum of strength and toughness lies nearer the more recently-formed heart-wood, or duramen. In some trees, indeed, no true heart-wood is distinguishable; but old stems have a "false heart" of decaying and discoloured wood

at the centre. For this reason it becomes a matter of great importance, in selecting timber for use—especially if it be intended for works of any magnitude—that logs should not be taken of dimensions much in excess of the specification given, but corresponding as nearly as possible in size to it, as the removal of more than a few of the outer layers of heart-wood is likely to involve a serious loss of strength.

It should be observed that a tree does not cease growing when it arrives at maturity. As long as it is alive, it continues to increase in bulk by the addition of the annual layers developed by the cambium; but when maturity is once passed, each succeeding year produces a certain amount of deterioration at the centre. This deterioration or decay appears in various stages, and generally exhibits, in the first instance, either a white or yellowish-red colour at the butt or root end of the stem. If white, the defect is probably very slight, and does not usually extend more than a few feet up; but if yellowish-red in colour, it is not unfrequently of a more serious character. Again, if the affected parts have assumed a decidedly red tinge, the tree is said to be, in technical language, "foxy," and is scarcely fit for constructive purposes, as the decay will be found to pervade a great portion of the tree. The further advanced stage of deterioration is that which may be described as a drying up or wasting away of the wood immediately surrounding the pith, or medulla. It forms a hollow, first at the butt, and then spreads upwards, gradually increasing in size as the tree gets older, while the defect may eventually reach even into the branches. Many of these forms of "rot" are directly due to parasitic fungi, and others are accompanied and hastened by the ravages of these organisms.

Trees are of course most valuable, as yielding the largest possible amount of good timber, just prior to the commencement of this change, which is indicated almost immediately it takes place by the topmost branches and branchlets becoming stunted and thick; being, in fact, what the surveyor or woodman would call "stag-headed." If, therefore, we wish to select a healthy tree for felling, we must seek for one with an abundance of young shoots, and the topmost branches of which look strong, pointed, and vigorous, this being the most certain evidence that it has not yet passed maturity.

Timber trees, immediately after they are felled, unless they have been previously killed, contain a great deal of moisture, and are, therefore, unfit for use until they have been somewhat seasoned. This is accomplished in a variety of ways, but the primitive and best mode is, probably, to leave it for a time protected from the weather, following as closely as possible the natural process, which consists simply of the gradual drying up, or evaporation, of this moisture, which would otherwise promote decay owing to its favouring the development of fungi, which feed on the organic substances dissolved in the water. Of the time required for seasoning, and the various means of accomplishing it, we shall have occasion to notice farther on; suffice it to say at present, that as the wood which needs the least seasoning is generally found to be the most durable, it becomes an essential point that trees should be felled during the winter months, when the sap is present in its smallest quantity.

CHAPTER III.

ON THE FORM AND QUALITY OF TREES.

TREES grown in sheltered places run up quickly and to a great height, a fact of which advantage is taken in the early stages of growth of forests; such trees also produce the greatest length of clear stem, the development in the upper portions preventing the growth of branches low down. This is chiefly owing to the want of sufficient light and air to enable them to assimilate freely, and in situations where it occurs to excess the texture of the wood is soft in comparison with that of trees grown in the open. They have, however, the compensating advantage of being very free from local defects, and by gradually exposing them to the light after the principal growth in height has been attained, the best results are secured in the end.

Many trees, as, for example, the Oak, when grown in hedge-rows, or other exposed and isolated places where they are fully exposed to light and air, take a freer and, perhaps, more natural form of growth; the branches generally occurring lower down, and meeting with no obstacle to their development, they assume every variety of curve, and produce timber which is especially valuable for naval purposes. Timber thus grown is from the first of the hardest and most compact kind, although subject

to many defects from the want of shelter from cold winds and other exigencies of the environment, including the occasional breakages of the branches from various causes, and the injudicious lopping or pruning which is too often practised.

Trees grown in a copse might be expected to unite the leading characteristics of the two forms of growth just mentioned, inasmuch as, while the underwood remained, the upward tendency of the stem would be almost as strong as in a forest-grown tree, while each time the copse was cut, the branches would have perfect freedom of growth. It is, however, found that, although forming curved branches and a greater length of stem than can be met with in isolated trees, instead of the wood being uniformly harder, the changes to which the trees are subjected by the periodical growth and loss of the protecting underwood renders the quality of such timber extremely variable.

Variety of soil also exercises an influence, both direct and indirect, upon the quality of timber; trees grown in a dry, rocky soil having generally hard, compact wood; while the wood of those grown in swampy and moist situations will be found comparatively soft and spongy in texture. Variations of temperature, violent storms, or proximity to the sea or large rivers, and many other circumstances also affect the quality and rate of growth of trees.

It has long been known that the presence of trees tends directly to keep up and render more constant and uniform the water supply, and that the clearing of large forests results, in time, in the drying up of all the springs and watercourses in the neighbourhood. That such an effect is produced is certain, as attention was lately drawn to it by the condition of large tracts of land in

the South of France and in other countries, which, though long celebrated for their fertility, were rapidly becoming valueless. The change in the nature of the soil, consequent upon the partial drying up of all the sources of water supply, was proved to have commenced when the trees had been removed. At the same time, cases are known of districts where there had previously been a deficiency of water, until the extensive planting of trees remedied the defect.*

It would seem that the fine trees found in forests and elsewhere, whether it be natural to them to have straight stems or curved ones, have not always been so fair looking or so symmetrically shaped as we find them when of an age and size fit for felling, but that in early life they have not unfrequently assumed a wavy, rambling, or, it may be, unsightly appearance, which was only improved upon as they attained to greater strength and approached maturity. This supposition will, I think, be readily allowed by any one who has passed through a copse, or maiden forest, in search of a straight sapling for a walking-stick, and experienced the difficulty of finding one suitable for the purpose.

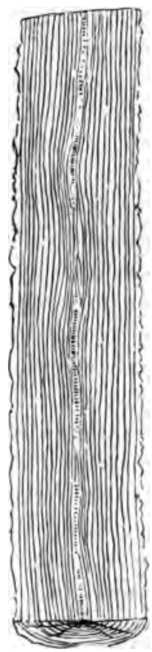

FIG. 7.

A short time since a piece of Oak timber of moderate

* The reader will find more details concerning these matters, and the direct and indirect utility of forests, in Dr. Schlich's "Manual of Forestry" (Bradbury, Agnew, & Co.), and in Nisbett's "British Forest Trees" (Macmillan).

dimensions came under my notice which fully illustrated this fact, as it had sufficient of its wavy and rambling form laid open, while under conversion for employment in ship-building, to satisfy the most sceptical that it could have had little of beauty to recommend it to notice during the first thirty years of its growth; while the large straight block of timber which encased it showed that later in life it had assumed a much fairer form, and was even considered, when viewed in the log, to be fit for any purpose where straight timber was required.

It is, therefore, clear that trees do not change or alter their form while young, except in a very slight degree; they appear rather to assume the fairer and more even growth later on, and very gradually. It may possibly be brought about by the matter which forms the zones of each succeeding year's growth contributing to one part a greater and to another a lesser substance of woody layer, as required to develop the fairer growth seen in the matured tree referred to. And hence, if we take a perfectly straight tree, and cut it through the middle longitudinally, we are pretty sure to see the pith running snake-like along its entire length (Fig. 7). Therefore, in timber having much heart-shake, there is certain to be considerable waste in its conversion, especially if we wish to reduce the log into plank and board.

CHAPTER IV.

ON THE DEFECTS FOUND IN TREES.

HAVING referred to a few characteristics of growing timber trees, it will perhaps be interesting if, before proceeding to a detailed account of the various kinds, we give a description of some of the defects to which trees are liable prior to their being felled and hewn, or otherwise prepared for the market.

There is one defect so common to nearly all trees that I will treat of it first. It is known to carpenters as the heart-shake. In typical heart-shake, we find the central parts of the stem show signs of hollowness, with radiating cracks around running more or less out into the younger layers; the widest part of the crack is nearest the centre of the stem, and this does not necessarily show obvious signs of rot or decay. It is met with to a greater or lesser extent in nearly every species of timber that we have to deal with, and as it has a very important bearing upon the value of the tree affected, we cannot afford to disregard it, inasmuch as the quantity of good and serviceable material obtainable from a log, depends almost entirely upon the distance we are constrained to go from the pith, or centre, in order to get clear of it. Experience has shown that among the woods least affected by the

heart-shake are African Oak, or Teak, as it is sometimes called; Sabicu; Cuba Mahogany; and English Elm; while Indian Teak * and Australian Tewart have it in a very objectionable form. These species are among the hard and strong woods used for architectural purposes in this country, and by cabinet-makers for the manufacture of furniture, and for other domestic uses.

As regards the white or softer woods, it is generally very small in the Dantzic, but extensive and open in Riga and Swedish Fir. In the Pines, the Canadian Red is perhaps the closest and least of all affected by it, the Canadian Yellow coming next in order; but in the Pitch Pine of the Southern States of North America it is often present in a more enlarged form, and the centre, or pith, of this species cannot well be approached if thin boards are required to be cut from it.

This defect, as before mentioned, affects and pervades more or less nearly every description of timber; it is common to all the dicotyledonous trees as well as Conifers, and neither soil nor situation appears to have anything to do with its origin. It must be accepted as an indication of incipient decay consequent on old age; the gradual loss of solid substance in the oldest layers of wood causing them to shrink more than the specifically heavier younger ones. Our study should be to so utilise the trees possessing it in its most extensive and objectionable form, as to employ them for purposes which entail doing as little as possible to them if we wish to convert the logs profitably. The heart-shake is so very insignificant in some timber, that many

* In India, the forest officers have attributed the heart-shake in Teak to the ringing, or barking, the trees, to kill them before they are felled. It has, however, been proved that, where this has not been done, and the trees were felled green, heart-shake was found in them.

persons, not professionally educated to the work, might look at a log without suspecting its presence. Others, again, if they did discover it, would hardly consider it to be of any importance, as it is often so small that the blade of a penknife could scarcely be thrust into it.

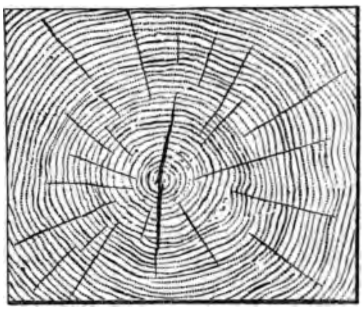

FIG. 8*a*.

There are, however, several varieties of timber which have it, not in an insignificant form or shape, but extending from the pith to a distance of about two-thirds the semi-diameter of the tree. This is of serious consequence to the converter who has to deal with it, as the defect completely separates the concentric layers into segments of circles. The simplest form in which we find this shake (Figs. 8 *a* and *b*), is that of a straight line crossing the pith, and taking a direction in the same plane through the length of the stem. It will, however, be found in some specimens to have taken a twisting form, and on examining the top of the tree, the shake may be nearly at right angles to that at the butt-end (Fig. 9). This is about the worst form, as it would involve a

FIG. 8*b*.

most serious loss in the conversion of the log if it were an object to reduce it into plank, and often necessitates its being employed in bulk.

FIG. 9.

The twist in the heart-shake just referred to looks like the result of an effort made by the tree to turn upon its base, and it has been supposed that it might happen to trees produced in dense forests, where light and air are very scant, or perhaps to trees unequally balanced in their branches, if grown in the open. There is more evidence, however, of its being due to the twisting in the spiral turns of grain noticed in many trees, and which is connected with the interpectination of the fibrous and other elements during the growth of the wood.* The heart-shakes are equally disadvantageous, if, indeed, they are not more so, when they cross each other at the pith, and open to the full diameter of the tree, splitting it into four segments.

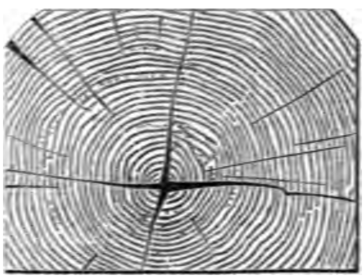

FIG. 10.

* This spiral growth is common in the Turkey Box tree; it is also frequently seen in the Fir and Pine species, and occasionally in other woods, *e.g.* Chestnut.

This form of the defect is very conspicuous in the Greenheart timber (Fig. 10).

The next important defect is the star-shake (Fig. 11). This is found in many varieties of timber, and occurs in trees of all ages and conditions of growth. It consists of clefts radiating from the centre, or pith, which often extend far towards—and even in bad cases touch—the circumference of the tree, rendering it almost valueless for conversion into board and small scantlings.

The clefts or lines forming the star are generally only slightly open, and can scarcely be seen in a fresh-cut tree, there being no obvious signs of decay about them. They are, however, very plainly perceptible when the wood is moderately seasoned, by the matter forming the two sides of the shake having become somewhat darker in colour and more horny in texture by exposure to the air.

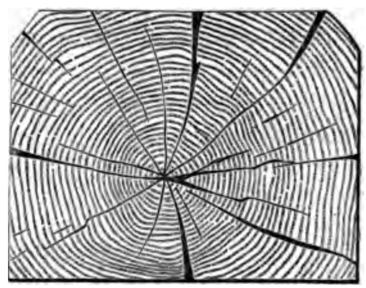

FIG. 11.

The principal cause of all such defects as those referred to, and to that condition of the central parts of many old trees, especially Beeches, known as *bois rouge* in France, is a more or less advanced stage of decay commencing in the pith and proceeding thence into the wood around. This decay consists in a gradual rotting and oxidation—*i.e.* combustion—of the wood-substance, essentially similar to the decomposition which all wood undergoes sooner or later, especially when exposed to alternating conditions of drought and moisture in

the air; and it is usually started in the standing tree by the loss of a large root or branch, which gradually opens the way to the air and moisture, and eventually, it may be, to minute fungi and bacteria which hasten the processes of decomposition started by the oxygen of the atmosphere.

Fundamentally, this process of decay is merely a phase of the process of destructive combustion which all organic matter is liable to in contact with oxygen. As the wood loses weight and substance, it shrinks more and more, and so we find cracks of various kinds as described.

It is, after all, merely the extension of these destructive processes which result in the hollowing out of old trees; though in these cases the phenomenon is usually accelerated—and often, indeed, started—by the ravages of certain fungi which gain access through wounds, such as broken branches, gnarled roots, and so forth.

As before stated, in bad cases the points touch the circumference of the tree; they even occasionally bulge there, forming a longitudinal rib, varying in length from about a foot to two or three yards. We have thus external evidence of the presence of the star-shake in this extreme case while the tree is yet standing. We can, therefore, from this alone, estimate its value, and prove the correctness of our opinion of it after the tree has been felled. No one, I imagine, experienced in timber-surveying, would, with the bulging rib in view, care to examine either the top or butt end of the log to satisfy himself of the presence of the star-shake; the guide is so absolutely certain that we need not fear to trust to it.

In these last cases, the cause of the radial crack is

almost invariably either *frost* or *sun-burn*, and it is usually possible to determine which by paying attention to the conditions.

The plane followed by the crack is that of the medullary rays, and the separation of the wood is due to its violent contractions, or shrinkage, and expansions during the process of rapid freezing from without inwards. In other cases, especially with smooth-stemmed trees such as the Beech and Hornbeam, the sun's rays kill the living tissues of the cortex, and longitudinal cracks result in the wood. Occasionally both frost and insolation are concerned.

It occasionally happens that defects of the nature of "cup-shake" are traceable to the base of the tree having been scorched by a forest fire. The cambium is then so baked on one side of the tree (or even nearly all round) that it is many years before the still living portions of the cambium can entirely cover over the dead parts, and the consequence is the production of a series of more or less irregular occluding layers* superposed over the hitherto regular and concentric annual rings. As the occlusion approaches completion, the burnt side of the tree shows external ridges and defects very like those due to sun-cracks or frost-cracks.

The cup-shake or ring-shake (Figs. 12 *a* and *b*). This shake, which is most frequently met with near the roots of trees, consists of a cavity or separation of two of the concentric layers, often accompanied by more or less traces of rot, if the injury is of long standing. This deficiency of cohesion between the woody layers is supposed to result from sudden changes of temperature, from the roots passing through a peculiar vein of soil,

* *I.e.* the subsequently developed annual layers of wood which gradually cover over (occlude) the injured part.

and even from frosts; violent and sudden gusts of wind and storms may also help to produce it. It is unquestionably, in some cases, due to the destructive action of fungi—*e.g.* Pines attacked by *Trametes Pini*—those parts of the wood injured by the fungus losing and taking up water more rapidly than the sound portions, from which they consequently contract away as shrinkage goes on.

Wood, as is well known, is a bad conductor of heat, and standing timber usually takes a considerable time to accommodate its temperature to that of the air.

FIG. 12*a*.

FIG. 12*b*.

Suppose a tree, with abundance of water in its wood, suddenly exposed to a prolonged and severe dry frost. The cortex and outer layers of wood freeze first, and, neglecting an initial expansion, the icy mass contracts and exerts considerable pressure on the inner parts of the wood; these latter gradually freeze in turn, and at a certain period in the process the stresses and strains may be so arranged that the outer parts of the woody mass have contracted so much, especially owing to

the drying of the wood-cell walls as their water freezes out in ice-crystals in the cavities, that any expansion of the inner mass may result in violent and sudden rupture. Such an expansion may result at a certain stage of the freezing of the inner woody cylinder, and the consequence is a *frost-crack*.

So far as such cracks are radial only, they come under the category of "star-shakes," as we have seen; but it is obvious that the sudden and violent rupture of these outer layers of wood may lead to separation of the whole mass of outer shells of wood from the inner ones, and such separations constitute "cup-shakes."

These latter may also result, however, especially in soft-wooded trees like Poplars, by the shearing action of violent winds, for in bending beneath the gusts the cylindrical shells of woody layers tend to be alternately compressed and extended on opposite sides, a process obviously calculated to cause the layers to separate at the softer parts and shell off.

It will sometimes happen that only a portion of a layer is detached, making the segment of a cup; at other times, a small part of several layers; and again, in some instances, we find that the disjunction is not complete, owing to there being a few fibres remaining to connect the two layers. When, however, it assumes its worst shape, that is, when the ring or cup is perfect, it will in all probability be found to pervade the greater part, if not the whole tree, evidence of it being frequently traceable in the remotest branches.

Experience has shown that with only a segmental cavity open, there is not much to fear, as it seldom extends far up from the root; any log, therefore, not having more cup-defect than this, may without hesitation be converted into plank, board, or scantling;

but if one or more complete cups be present, especially if they are large, it could not safely be sawn longitudinally down the middle, as the centre or cup part would drop out, leaving in each half a deeply-grooved channel, equal to the semi-diameter of the cup-defect. The log in this case could, therefore, only be used advantageously by appropriating it to some purpose where the full growth might be employed.

The cup-defect occurs in perfectly sound and healthy-looking trees, and there is not anything to indicate its presence to the surveyor while the tree is standing. It can only, therefore, be dealt with when discovered in the log, after being felled. This defect is, to some extent, local, and is especially so among the Oaks, it being more frequently met with in the Sicilian Oak tnan in, perhaps, any other. It occurs in Virginian Pitch Pine, and it is often found in Lignum Vitæ. It is worthy of notice that whatever may be the cause of the cup-shake in the last-named wood, which is grown extensively in St. Domingo, latitude 18° to 20° N., and where the temperature of the winter is rarely below 60°, it cannot have suffered from frost.

CHAPTER V.

ON THE DEFECTS IN TREES—(*Continued*).

WHERE woody layers of irregular growth are found in timber, especially if there be alteration of colour extending over any of them, they may be considered to indicate that the tree was not at all times in a healthy state, but that it had suffered from some cause, or from the failure in the nourishment it required to perfect the layers with regularity.

Any departure, therefore, from the natural colour peculiar to the species, whether it embrace one or more concentric circles, or be locally situated, is prejudicial to the wood, and generally, if tried under the adze or plane, it will be found brittle and deficient in tenacity. Such logs should on no account have the preference of selection for important services in works of construction, but should be used only for minor purposes, if at all. I have noticed this defect in many varieties of trees, but in none is it more conspicuous than in the Kauri of New Zealand, these noble Conifers being peculiarly liable to this whenever they stand exposed upon the north or equatorial side.

We occasionally see spots in timber, quite foreign in colour to that which is natural to it ; they may be seen in all parts, but are most common at or upon the butt-

end of the log. These are not often of a very serious character, but are nevertheless the early or first stage of incipient decay, and will be found less able to resist the action of water, or oxidation and destruction consequent on alternate drying and wetting, than the wood of the same log which is untainted. Although these spots can hardly be reckoned as hopeless defects, seeing that, they do not penetrate deeply enough to affect in any appreciable degree the value of the timber, the surveyor would do well not to employ such logs in architectural works where it would be difficult to replace the piece should it at any time be found to be decayed.

A swelling upon the exterior of a tree is generally a sign of some defect being hidden beneath; it may be confined to the alburnum, but it may also conceal a serious fault that would be highly detrimental to its value.

The excrescence should, therefore, be removed as soon as the tree is felled, in order to clear up the existing doubt. There are, however, some few exceptions to this; for instance, the burrs which are found upon the Oaks of some districts,* and the Austrian and Turkey Walnut tree burrs, which are very finely mottled and figured, make good veneers, and have of themselves a special value for cabinet purposes.

The removal of a branch of moderate size from a tree, close down upon the stem, will generally be concealed by a swelling of the kind first mentioned, particularly if it has been done while the tree was in a healthy state and annually forming new wood. Such

* These peculiar excrescences are supposed to be caused by puncturations of the bark by insects, while the tree is growing; but, so far as I am aware, the quality of the trunk of the tree is not often affected by it.

hidden knots are frequently in a state of incipient decay, owing to the rain and the moisture of the atmosphere having entered by the wound, and fostered the development of various rot-fungi, the spores of which were washed in, before it became hermetically sealed; and, as it generally takes a long time, even many years, to completely heal it over, it would during all that while be steadily producing decay in the fibres, etc., running from the knot to the centre of the tree; the diseased or affected part, when opened, being often found spread to a very great extent, and in bad cases emitting an unpleasant odour.

FIG. 13.

The disease thus occasioned first attacks the alburnum, and the wood-tissues immediately surrounding the centre of the knot, and then passes downwards, following the direction of the wounded branch towards the pith of the bole or stem, after which it rises in the various elements conveying the sap, and is often communicated to other parts of the tree, and does very great mischief.

It will sometimes happen that this disease is concentrated, or confined to the root-end of the branch,

producing there what is technically termed a "druxy knot." This defect, if prevented from spreading by the otherwise healthy and vigorous state of the tree during its growth, must still be looked to after it is felled, since, if neglected, there being no longer any check to its development, fresh moisture will be absorbed, decay will be accelerated, and the whole log soon destroyed. To guard against this, it would be proper, as soon as the log is appropriated for any purpose, to take out and completely remove the affected part, substituting in its place a piece of sound wood.

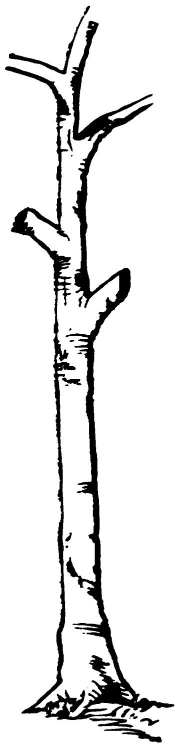

FIG. 14.

Again, the damage done by the breaking of a branch from a tree is often very serious, as illustrated in Fig. 13. The wound was of very old standing, and entirely healed over, but the decay had nevertheless made steady progress. It was found, by counting the concentric layers, that the branch was broken when the tree was fifty-six years old; that in twenty-three years more the annual layers had completely covered the broken part, while outside this twenty-third layer there were twenty-seven years' growth of duramen or heart-wood, and twenty-six years' growth of alburnum or sap-wood, the tree having been about 132 years old at the time of its being felled.

Pruning closely, except in the case of very young trees, where the branches are small, and the wound is certain to be soon healed over, will, as before shown,

be attended with some danger, and should not, I consider, be done if it can be avoided. The safer plan with trees of moderate growth is to let a part of the branch remain if it is still living and capable of putting out foliage; say a foot or two in length, taking care at the same time not to leave it rugged at the end.

It should be neither cut horizontally nor square to the branch, but perpendicularly, or in the direction most certain to prevent water lying on the surface (Fig. 14).

If the branch is dead, or will soon die, however, it is absolutely necessary to cut it as close to the stem as possible, in order that the sound cambium of the latter may cover the wood as soon as possible. In all cases where feasible, it is a good plan to cover the wound at once with hot tar.

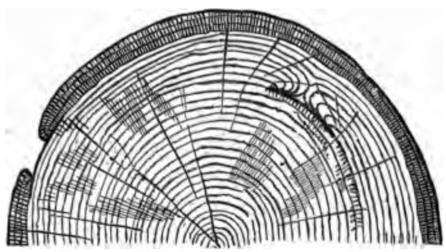

FIG. 15.

A tree is occasionally wounded and damaged by a blow. It may have been struck by the fall of another contiguous to it, or in some other way—*e.g.* by the scorching of a ground fire; such bruises, etc., often penetrate no farther than the bark, and simply leave evidence of it later on, in what is technically termed "rind-gall" (Fig. 15). This is a defect, inasmuch as the concentric layers at this part are not organically united, but simply deposited over each other; but there is usually no decay of the wood. If, however, the injury be more severe, and the alburnum and duramen are contused, the wounded part no longer resists, but largely absorbs

moisture, which tends directly to decompose it, and, decay having once set in owing to the penetration of fungi, a species of rot soon supervenes, to the detriment of the tree. This is often difficult to discover while the tree is standing, as, unless the blow is of quite recent date, the bark will have grown over it again, and effaced every trace of the wound.

The cases of "cup-shake" due to forest fires come under this heading also.

The following remarks on the selection of timber, etc., may be useful :—

In selecting timber, the surveyor's attention will naturally be given to an examination of the butt or root end, which should be close, solid, and sound ; and if satisfied in this respect, the top should next be inspected, to see that it corresponds with the butt-end. Afterwards he will glance over the exposed sides in search of defects, carefully examining the knots, if any, to see that they are solid. He will, of course, avoid any piece that has either heart, cup, or star-shake, or sponginess near the pith at the butt, discoloured wood at the top, split along the sides, rind-gall, worm holes, or hollow or decayed knots.

In dealing with spar-timber, he will select the straightest pieces ; they should be free from all the defects before mentioned, upsets, *i.e.* fibres crippled by compression, large knots, and even those of moderate size if they are numerous or situate ring-like round the stick. Spar-timber should be straight-grained.

As planks, deals, etc., depend for their usefulness upon both quality and manufacture, the surveyor will not only see that they are free from excess of sap, knots, shakes, and shelliness upon their sides, but also that they are evenly cut and fit for use of their thickness.

Bright-looking timber is better in quality than dull, and that which is smooth in the working better than the rough or woolly-surfaced.

The heart of trees having the most sap-wood, is generally stronger and better in quality than the heart of trees of the same species that has little sap-wood.

CHAPTER VI.

EXPERIMENTS ON TIMBER.

HAVING treated of the principal defects to which timber trees are liable during their growth—and perhaps they are all that need be now considered, as others of a less important character will be noticed later on, whenever they affect any particular class of wood—I will pass for the present to the description in detail of the various timber trees, observing, by the way, that the tables appended are the results of experiments made transversely, tensilely, and vertically on specimens taken from the wood of the tree described. In some cases these are very numerous, and will be, I consider, invaluable, as showing the range and variation of the strength and specific gravities of each wood; further, they include some rare, and at present scarcely known, species of timber, which may at a future day be in request in this country for building purposes.

It need scarcely be stated here, since it will be well understood, that to classify and collect the notes in order to record these tests of strength, etc., in timber, it has taken a very long time, and, but for the exceptional opportunities I had during a long course of service in the royal dockyards and elsewhere, it would have been impossible for me to have obtained these results.

While employed surveying timber for the Navy in

New Zealand, and subsequently in India, Belgium, France, Prussia, Asia Minor, and European Turkey, and also in the royal forests in England, and later on as Timber Inspector of a dockyard, and Timber Inspector to the Admiralty, every effort has been made to acquire a knowledge of the capabilities and characteristic properties of the several varieties of timber which came under notice.

Many of the experiments to which I shall have to refer were made at Woolwich Dockyard, where it was necessary, as a part of the duty of my office, to ascertain the specific gravities, strength, and measurement, and attend to the receipt of the timber coming in under contract with the Admiralty.

Especial care was taken to carry out the experiments upon wood brought to a well-seasoned condition and fit for appropriation to works of construction ; and in many instances we have tried not only a number of pieces taken from different trees, but a series of pieces from the same tree, with a view to find, if possible, in what part the maximum of strength lay.

Formerly, I believe, it was the practice to carry out these experiments upon exceedingly small pieces of wood, and I have seen it stated that some were no bigger than a French line, = ·0888-inch measurement, and varying in size from that to about one quarter of an inch of English measure, the result per square inch being obtained by subsequent calculations. This was probably done in consequence of the great difficulty there is in securely holding, and bringing a sufficient strain to bear upon and break the larger scantlings. I should not, however, be disposed to place much reliance in the results so worked out, as it would seem to be impossible to reduce pieces of wood to such small dimensions

without cutting across some of the fibres, and thus unnecessarily weakening those which remain. There are, undoubtedly, many examples to be found where larger scantlings have been experimented upon, and the results of these are, of course, more reliable and trustworthy.*

The tests for the transverse strength in my experiments were conducted, in every case, with pieces 2″ × 2″ × 84″ = 336 cubic inches. Each piece was placed upon supports exactly 6 feet apart, and then water was poured gently and gradually into a scale suspended from the middle until the piece broke, note being taken of the deflection with 390 lbs. weight, and also at the crisis of breaking.

After this a piece 2 feet 6 inches in length was taken, wherever it was found practicable, from one of the two pieces broken by the transverse strain, and tested for the tensile strain by means of a powerful hydraulic machine, the direct cohesion of the fibres being thus obtained with great exactness. Further, for the purpose of determining the proportions of size to length best adapted for supporting heavy weights, a great many cube blocks were prepared, of various sizes, as also a number of other pieces of different form and dimensions, which were then, by the aid of the same machine, subjected to gradually increasing vertical pressure in the direction of their fibres, until a force sufficient to crush them was obtained.

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* Among the best of these made in recent times, the reader will find Bauschinger's *Mittheilungen aus dem Mech. Techn. Laboratorium*, 1883 and 1887, referred to in Unwin, "The Testing of Materials of Construction" (Longmans, Green, & Co., 1888). For American timbers, Lanza, "Applied Mechanics," and "Report on Strength of Wooden Columns." For Indian timbers, Gamble, "Manual of Indian Timbers," 1881. For Australian timbers, Maiden, "Useful Native Plants of Australia," 1889. And for many Colonial timbers, "Reports of the Colonial and Indian Exhibition (1887)."

CHAPTER VII.

ON THE SEASONING AND PRESERVATION OF TIMBER.

THE properties and characteristic qualities of the various species of timber being known, it will be easy for any one engaged in engineering or architectural works to select the particular species or kind most suited for his purpose; he will also, by the aid of the tables of experiments upon the several varieties, be enabled to determine the scantlings, and thus economise the process of conversion.

As will be stated later on, from observations extending over many years, Oak and other timber felled during the winter is preferable for constructive purposes to that felled in the spring or summer months; but this must be taken only as applying to the deciduous trees, there not being, so far as I am aware, any difference in the wood of the evergreens whether they are felled in the winter or the spring months. As regards the former class, however, I have carefully examined and compared a great many pieces of both winter and spring or summer felled logs, and found, almost invariably, that the winter-cut timber, after being a few years in store, was in better condition than that which had been cut in the spring. Both, be it observed, having been under similar treatment for preservation.

The winter-felled logs were sounder, less rent by shakes, and the centres or early growth generally showed less of incipient decay than the spring-felled. The centres in both, however, unless they are carefully protected from the weather, are liable to be deteriorated at the ends after being about three years in store, and if exposed for a longer period, the deterioration will be more serious, inasmuch as the shakes will be deeper and more open, and instead of the early stage of decomposition at the ends, there may be decided rot supervening, and involving great waste whenever it is required to be brought into use. The Tewart of Australia and the Greenheart of Demerara are, however, notable exceptions to this, for on these two woods time and weather have little effect; they seem to be almost imperishable.

While the above is true of the timbers of Europe and cold temperate countries generally, however, there are other considerations to be noted in hot climates. In India, for instance, the season of felling should be as cool and moist as possible, to ensure the *slow* drying of the wood and therefore the minimum of cracking; but it often happens that malarial periods and heavy rains prevent this. In hill countries, again, the snow and rains compel fellings at seasons otherwise not preferable. Then, again, the purposes for which the timber are to be employed are important; firewood should contain all the solid materials possible, and be dried rapidly, and the best season for this is often that of drought and heat.

Ten or twelve years seems but a short time compared with the usual and common duration of timber, and when we hear of the timber framework and fitments of old buildings being found in a sound state after having

stood the test of ages, I think it should be understood that it could only have been under certain very favourable conditions.

First. That the timber was of good quality when selected for employment.

Secondly. That it was at least moderately seasoned when brought into use.

Thirdly. That it was placed in a favourable position in the building for lasting, and where it had a free circulation of air about it, without being in a draught.

Fourthly. That the temperature was moderate and regular, and not subject to sudden calorific changes, or even to too strong a light.

The most effectual way to preserve good timber is to partially season it in as natural a way as possible before working it up, and to give it simply that protection when brought into use which all other materials require to keep them from perishing. It should not be too soon varnished, painted, or coated with any preservative compound whatever, but be allowed to undergo after conversion a further short process of the natural seasoning before this is done. Its durability will be thus ensured much more effectually than if desiccating, charring, or some other rapid process of seasoning had been resorted to, for the sake of bringing it into earlier use after being felled.

My experience of the approximate time required for seasoning timber under cover, and protected from wind and weather, is as follows:—

Pieces 24 ins. and upwards square,			Oak,	require	about	26 mths.	Fir,	13 mths.
Under 24 ins.	to	20 ins.	,,	,,	,,	22 ,,	,,	11 ,,
,, 20	,,	16 ,,	,,	,,	,,	18 ,,	,,	9 ,,
,, 16	,,	12 ,,	,,	,,	,,	14 ,,	,,	7 ,,
,, 12	,,	8 ,,	,,	,,	,,	10 ,,	,,	5 ,,
,, 8	,,	4 ,,	,,	,,	,,	6 ,,	,,	3 ,,

Planks from one-half to two-thirds the above time, according to the thickness.

If kept longer than the periods named, the thin fine shakes which first open upon the surface during the process of seasoning will open deeper and wider, until they possibly render the logs unfit for conversion. If, however, the logs be reduced to the scantlings required after partial seasoning, and then further allowed to dry, they will not be liable to tear open so much, but by shrinking gradually will retain a more solid form, and be less objectionable to the eye when placed in position.

The table showing the time necessary for seasoning the various scantlings must be qualified by the consideration that in the case of any foreign timber that will float, the foresters and raftsmen, while transporting it to the port of shipment, often, and quite unintentionally, do good service in giving it some weeks, if not months, of water seasoning, which should be estimated for in determining its fitness for use, whether it be as a substitute for Oak or otherwise.

Square Fir timber, and rough spars for masts, are often kept too long afloat after they are purchased, under the impression that they will soon be wanted, and therefore their temporary submergence is hardly worth while. Yet, perhaps, from some cause or other, they are not brought so quickly into use as was expected, and months, even years, may pass by without much thought being given to them. The consequence is that just about the line of flotation, and that part which the water washes, the logs are often found to be seriously deteriorated, owing to the invasion of fungi which require air as well as water, and which therefore could not

flourish if completely submerged. To ensure the preservation of this wood it will therefore be necessary to submerge it without delay.

In cases where it is not convenient to submerge the timber at once, it would do some good if the logs were occasionally turned over. It is a little difficult, however, to accomplish after one-half the log is soddened with water, as then it can only be managed if secured in rafts, and it is almost impossible to permanently change the position of a log, if it be crooked, from that which it naturally takes by its own gravity in the water.

To aid the natural seasoning, and bring about at the earliest possible time the evaporation of the moisture which is contained in all newly-felled timber, the trees should not be allowed to remain long upon the ground where they grew, as the soil is generally damp and wet. They should rather be carried off as early as convenient to the timber yard, and stored there for preservation.

One of the earliest causes of decay may be accounted for by the way in which valuable logs of timber are too often left to sink by their own weight into soft earth, where they absorb a large amount of moisture, and are sure to be infected by the spores of destructive fungi. All logs, therefore, as they are brought in, unless stacked at once, should be blocked or skidded off the ground, as a temporary measure; it involves little trouble, and will amply repay the cost of labour.

In stacking timber the following suggestions may be useful:—

First. Let the skidding as a rule be placed as nearly as possible level both ways, and in no case allow the

upper side of it to be less than 12 inches distant from the ground; it will then necessarily follow that, whether the stacking ground be level or upon the hillside, there will be ample space for ventilation under the timber to be piled thereon.

Secondly. Let the butt-ends of the logs be placed to the front, and keep the back or top ends of each tier slightly higher than the butts, for facility in withdrawing them from the stack.

Thirdly. Let the skidding over each tier of logs be level, and place short blocks under it, as packing pieces 1½ or 2 inches in thickness upon every log; the advantage of this is, that by removing the packing pieces any log in the tier, between the two layers of skidding, may be withdrawn from the stack without disturbing the remainder.

Fourthly. If the timber to be stored cannot be placed in a permanent shed, it should, with the view to its preservation, have a temporary roof placed over it. The size of the stack should therefore be considered in setting it out, limiting the breadth or span to about 25 or 30 feet.

Fifthly. Let each tier as it rises be set back 6 to 8 inches, to enable the converter to get over it without a ladder; he will find it convenient for examining and selecting his logs for conversion.

These rules were carefully carried out at Woolwich Dockyard, where for some few years previous to its being closed, an immense quantity of timber was kept. The stacks, besides being covered in, had the sides and one end also screened from the weather; all this was done with the coarsest description of board in store, and such as could not have been used for joiners' general purposes.

The boards forming the screen at the sides were slipped into a groove at top and bottom, and a rail or fillet midway up and outside was secured to the inner framework of the shed by nails driven between the edges of the boards. No other fastening was required, and the advantage of the plan was this—it allowed sufficient play for the boards to shrink or expand according to the weather and the season, while they were still removable at pleasure for any other purpose.

The end or working face of the stack was similarly closed up, but in this case, the boards being more frequently shifted, they were, for convenience, clamped together in twos and threes, and secured with a shifting bar half-way up. The timber was thus well protected from the weather, and well ventilated, though not subjected to a draught; and, in 1869, Woolwich yard contained probably the finest and best-preserved stock of timber in England.

It will be seen, then, that the preservation of timber may be cheaply and economically effected, and its seasoning brought about in a steady and regular manner by the adoption of the simplest precautions. Experience has shown that this is the only certain method of ensuring its durability, and it is therefore fit that the best attention should be paid to it.

Sheds of a cool, dry, lofty, and permanent character are required for the proper seasoning of thick-stuff, planks, and deals; and it is desirable that the stacks of each of these should be of a moderate breadth only, a passage through the middle of the shed being necessary for the convenience of examining and working each parcel. The ground skidding should be like that of the timber stacks, placed level, and be at least a foot in

depth, to admit of a free circulation of air throughout; upon these the planks, etc., should be laid flat, and open at the edges. Each tier should, as it rises, be blocked with dry battens $\frac{3}{4}$ to 1 inch in thickness, by at least 3 inches in breadth for deals; and 1 to 3 inches thick by at least 4 inches in breadth for plank, etc. These should be placed immediately over the ground skidding, as by so doing it will prevent buckling or warping, and keep the planks straight and fair-looking; and further, care should be taken not to stack too high, lest the upper tiers should feel the effects of the sun's heat through the roof.

Boards may either be placed on end and blocked from each other by pegs or battens, or be placed upon racks fitted horizontally to receive them for seasoning. The former plan is in much favour in many places, and especially so in small private yards, where they usually stand in the open. I much prefer, however, a dry, cool shed, fitted with horizontal beams and vertical iron bars, to prevent the boards which are placed on edge from tilting over, and believe that the wood shrinks gradually, more evenly, and is less damaged by splits or shakes than by any other method. Boards season surprisingly well in this way, and when it is considered with what ease and facility they are worked in and out of the frame, there is, I think, much to recommend the plan to favourable notice.

Duhamel considered that by setting timber upright it would season quicker, if not better, than if it were placed horizontally; it is, however, very difficult to do if dealing with large quantities, and is seldom practised. I rather doubt the efficacy of the plan. Fincham did not go quite so far, but experimented on timber placed upon

frames set at an angle of about 30°, and it was found that it afforded no good results. The butt-ends dried far too quickly to allow the sap juices, which drained to the lower part, to evaporate ; as a consequence, decay was rather accelerated than otherwise.

Steaming or boiling unseasoned timber will fit it quickly for employment in architectural work, but it should only be resorted to in case of necessity, as it takes from its strength, and adds nothing to its durability.

Seasoning in chambers heated to a high temperature is practised to some extent on thin planks, boards, and other small and light material, but it cannot be carried out on timber of large scantlings, owing to the great weight and the difficulty there is in handling it ; besides, the storage room required for any considerable quantity of it would be so enormous that it may be looked upon as next to impracticable. Very great care is necessary in drying boards by this desiccating process ; the ends need always to be clamped to prevent them from splitting and warping, and they must be firmly secured by thin laths being placed between them. Ordinarily wood thus dried loses in strength, and in coloured woods there is this further drawback, that they generally turn pale and lose their lustre.

A patent was taken out in France about the year 1861, by M. de Lapparent, Director of the French Dockyards and Inspector of Timber for Naval Purposes, for carbonising timber by means of inflammable gas (either pure hydrogen, or, better still, lighting gas) directed by means of a tube against every part to be carbonised, just as one would direct a jet of water from a fire-engine upon the flame to be extinguished. No doubt

the principal action is to destroy all fungi and spores present on the surface, and render the wood less liable to infection. A trial of it was made at Cherbourg in presence of the Director of Naval Works and numerous other witnesses, and it is said this was crowned with complete success. The absence of all danger from fire was clearly proved, and this of course removed the principal objection to its introduction in the dockyards. The cost, it appeared from calculations made at the gas-meter of the town, with the aid of an accountant, did not exceed one penny per square metre for gas and labour together.

M. de Lapparent holds that, the surface being once thoroughly dried, the juices of the interior will remain inactive—or, more accurately, they are not so exposed to the action of ferment fungi—and the durability of the timber be thereby ensured.

I experimented with this process at Woolwich in 1862, by charring seven out of twelve pieces of winter-felled British Oak, prepared to a scantling of 2″ × 2″ × 84″, and disposed of them as follows: for instance, Nos. 3, 7, 8, 9, 10, 11, and 12 were carbonised, and Nos. 1, 2, 4, 5, and 6 were not carbonised. Of the former, Nos. 3 and 10, and of the latter, Nos. 1 and 2, were suspended in a dry place in the store-room; Nos. 7, 8, and 9, and Nos. 4, 5, and 6, were put into a box of manure; Nos. 11 and 12 were driven half their length into damp earth, on the stacking ground.

I examined these specimens in 1863 and 1864, and they all appeared to be as strong and sound as when first prepared; they were therefore returned to their places. I again examined them in 1867, and then tested them for transverse strength. The results are given in the following tables:—

TABLE II.—CARBONISED BRITISH OAK.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight required to break 1 square inch.	
	Inches.	Inches.	lbs.		lbs.	
3	2·45	4·45	660	626	165·00	Kept dry in the store-room.
10	2·55	4·55	690	622	172·50	
Total .	5·00	9·00	1,350	1248	337·50	
Average	2·50	4·50	675	624	168·75	
7	3·00	4·25	345	1036	86·25	Kept in a box of manure.
8	3·50	5·00	490	1095	122·56	
9	3·25	5·75	530	1080	132·50	
Total .	9·75	15·00	1,365	3211	341·25	
Average	3·25	5·00	455	1070	113·75	
11	—	—	—	—	—	
12	2·75	4·50	480	946	120·00	

REMARKS.—No. 3 broke with scarph-like fracture, 5 inches in length; 10 broke in three pieces, each with scarph of 6 inches; 7 broke with long splintery fracture; 8 broke with splinters, 12 inches in length; 9 broke with splinters, 9 inches in length; 11, lost; 12 broke off short in three pieces.

TABLE III.—NON-CARBONISED BRITISH OAK.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight required to break 1 square inch.	
	Inches.	Inches.	lbs.		lbs.	
1	2·00	3·75	700	643	175·00	Kept dry in the store-room.
2	2·50	5·00	770	650	192·50	
Total .	4·50	8·75	1,470	1293	367·50	
Average	2·25	4·375	735	646·5	183·75	
4	2·75	4·15	485	1064	121·25	Kept in a box of manure.
5	3·50	4·50	420	1085	105·00	
6	3·50	4·35	440	1090	110·00	
Total .	9·75	13·00	1,345	3239	336·25	
Average	3·25	4·33	448·33	1079·66	112·08	

REMARKS.—No. 1 broke with scarph-like fracture, 7 inches in length; 2 broke in three pieces, each scarph-like, 7 inches in length; 4 broke with scarph-like fracture, 14 inches in length; 5 broke rather short, with small splinters; 6 broke with scarph-like fracture, 8 inches in length.

All the specimens that were kept dry, whether carbonised or not, were apparently in good condition; but those which had been placed in manure or damp earth were more or less in a state of decomposition, the softer parts of the concentric layers being slightly wasted away with rot on the surface. The difference in strength between the carbonised and non-carbonised pieces was not very great, but the tables show that of the pieces kept dry, the loss of strength was greatest by about 8 per cent. in the carbonised specimens; and of those kept in manure, the loss was about 1½ per cent. in excess on the non-carbonised pieces. When the experiment for testing the strength was completed, the broken pieces of Nos. 4, 5, 6, 7, 8, and 9 were again placed in the box of manure.

The weight of the specimens, taken on five occasions in nine years, was as follows:—

TABLE IV.

Number of the specimen.	December, 1862.	June, 1863.	September, 1867.	July, 1869.	April, 1871.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
1	12 3	7 13¼	7 13	—	—
2	12 6½	8 0½	7 15	—	—
3	12 2	7 11¼	7 9¾	—	—
4	12 9½	13 1¾	12 15	9 2	7 2
5	12 2½	12 10¾	13 5	10 12	7 8½
6	12 8	12 7¼	13 3	11 2	8 0¾
7	12 8	12 12¼	12 9½	10 14	7 3¼
8	12 12	12 9¼	13 5½	11 6	7 12
9	12 6	12 9½	13 2	9 12	7 5
10	12 3½	7 10¼	7 9	—	—
11	12 8¾	—	—	—	—
12	12 13¾	—	11 8	—	—

Nos. 11 and 12 were left in the ground in 1863, but No. 11 was missing in 1867. Nos. 1, 2, 3, 10, and 12 were lost at the closing of the dockyard in 1869,

but the broken pieces in the box of manure were safe, and these I kept until the yard was completely cleared of all its stores in 1871. At that time their condition was as follows:—

No. 4. Both pieces were considerably wasted.

No. 5. One piece much wasted, the other less so.

No. 6. Neither piece much wasted.

No. 7. Both pieces much wasted.

No. 8. On one piece some carbon remained; the other was much wasted.

No. 9. Ditto ditto.

The decay and waste between July, 1869, and April, 1871, was very rapid, but the condition of the carbonised and non-carbonised specimens was much the same; it leaves, therefore, little to say in favour of the charring process, and I should not myself be inclined to use it on timber for works of construction, except as a possible means of preventing the generation of moisture or fungus where two unseasoned pieces of wood are placed in juxtaposition.

An experiment in carbonising was tried on a piece of plank 5 feet in length, one-half the breadth being charred, the other not; this was set in the ground under the drip of a roof. In another case a piece of plank was charred over half its length, the other not. Plates of iron were then secured to each end, and the whole immersed in water to ascertain whether the carbonising of the surface would prevent oxidation. When, however, each of these was examined, some six months later, it could not be seen on which side to give the preference.

The wood backing to the armour plates on the starboard side of H.M.S. *Caledonia* was charred by M. de Lapparent's process, with the view to test its efficacy

thoroughly, and when this ship comes under repair it will be ascertained by comparison with the other side how far it is useful in preventing decay. The Admiralty also ordered the faying surfaces of the frame timber and planking of the *Tenedos* and *Spartan*, the former building at Devonport, and the latter at Deptford Dockyard in 1868, to be carbonised by this process, in the hope that it will retard the formation of fungus on the surfaces, on which it frequently forms with rapidity; but, as neither of these ships has yet been opened for repairs (1875), it is uncertain whether any good results have come of the experiment.

Experience has shown that many soluble substances of a poisonous or antiseptic nature, will delay or prevent the processes of rot or putrefaction to which all timber is liable. Modern botanical research has proved that this is owing to the fact that the poisons used kill the spores and mycelia of the various parasitic and other fungi which destroy the timber by (1) feeding upon the substances in the wood-elements, and (2) piercing the walls of the latter, or even dissolving them, and so weakening the structure.

But experience has also shown that there are enormous difficulties to be overcome before a piece of wood can be interpenetrated by any solution, however dilute. These difficulties never are overcome in practice, because where large pieces of timber are to be operated upon it is impossible either to give the time or to apply the pressures necessary for forcing the solution into the deeper layers of wood.

In discussing this subject it must never be forgotten that wood is not a mere porous body, like a piece of brick or gypsum, but that it has a complex structure, as already described in the introductory chapters. This

structure is intimately related to, and adapted for the conduction of fluids (containing dissolved salts, etc., and therefore comparable physically with the fluids to be injected) from the base to the apex, and *vice versâ*. As the trunk, or branch, ages, however, its inner portions undergo the changes which convert them into heart-wood. Now these changes are principally of two kinds. In the first place the elements of the heart-wood are more and more shut off, by peculiar structural changes, from partaking in the function of transport of water, therefore rendering it more and more difficult for air or liquids to traverse their walls; and, in the second place, these walls and the cavities of the elements become blocked up with such materials as resins, tannin, colouring matters and the like, and thus the heart is rendered more and more impervious to such fluids as we refer to.

Exact experiments prove that it requires very little pressure to inject the sap-wood of a Conifer or Dicotyledon with any coloured solution capable of wetting the walls, if the pressure drives the fluid up or down the stem; whereas very much higher pressures are needed to even partially inject the heart-wood in the same way. Again, while it is still comparatively easy to press such liquids through the sap-wood in a horizontal direction* at right angles to a medullary ray, it is almost impossible to drive them in one parallel to the ray, even in the sap-wood.

This being the case, it only remains to add that the timber of different species of trees differs considerably as to the depth to which it can be injected with antiseptics, and as to the pressures necessary to force the fluids in; and that, while it remains true that no large

* In all these statements concerning direction I assume the tree trunk to be in its normal vertical position.

piece of timber can be thoroughly injected, it is found in practice that the penetration of the antiseptic to even a few millimeters below the exposed surface of the wood, enhances its durability considerably—how much, depends on the nature of the antiseptic and the conditions to which the treated wood is exposed.

The following are the principal antiseptic substances in actual use for these purposes:—

Cupric sulphate, or sulphate of copper, is sometimes used for sleepers in France. It is cheap, very soluble, and easily applied; but as it merely deposits in crystals in the dried wood, it renders the timber brittle and is easily soaked out in drainage water.

Creosote, or rather tarry oils with a large proportion of creosote in them, is cheap where coal is abundant. The creosote is absorbed into the substance of the walls of the wood-elements and is not washed out, while the oily nature of the mixture renders the wood more pliable and damp-proof, and less liable to splinter, etc.

Mercuric chloride, or corrosive sublimate, is used in the process of kyanising—named after the inventor, Kyan—and is the most effective poison known for fungi, insects, etc.; moreover, this salt forms insoluble compounds in the wood, and is therefore permanent. Unfortunately, however, it is very expensive, and its exceedingly dangerous characters as a poison are against its general use.

Other substances which have been employed are *zinc chloride*, which is cheap but inferior to creosote; *carbolic acid*, which is, however, too expensive to compete with creosote; *tar oils*, *paraffins*, *benzene*, etc., etc.

As to the methods of impregnating timber, the most primitive is to paint the wood, preferably dry, as thickly

as possible, and trust to soakage; tarred timber is very commonly employed on this principle. The chief drawbacks are that the liquid soaks in a very little way, and any crack opened after treatment exposes the raw surface of the wood to the agents of decay.

The next simplest method is to submerge the logs, poles, etc., in a large bath and leave them there as long as practicable; in certain cases the bath is heated, even to boiling, with more rapid results. The principle of this method is exactly the same as that concerned in water-logging; the air in the cavities of the wood-elements is gradually displaced, more or less as the case may be, by the liquid, and obviously this displacement is hurried and rendered more complete if the liquid is hot enough to cause the imprisoned air to expand and escape. Experience shows that long submergence may render the timber brittle, and the results differ with different species of wood. Tar, sulphate of iron or of copper, chloride of zinc, and creosote have been used in this way often with excellent results, though the liquid only enters a very little way into the sleepers, poles, etc., treated.

A somewhat more complicated and more costly process has been employed with great success of late years. This consists in placing the sleepers, telegraph poles, etc., in air-tight chambers, which are then partially exhausted, so that some of the air in the wood escapes. Then the chamber is filled with the solution—usually creosote, but salts of copper or zinc, or tar, ferric tannate, etc., have been used—which is allowed to soak in, either at the ordinary atmospheric pressure, or under pressures applied by force-pumps.

Even more effective, with creosote, is this method combined with the heating of the whole apparatus; or

steam, saturated with the preservative, is forcibly driven in. The chief advantages claimed for this process are (1) that unseasoned wood can be effectively treated, (2) the antiseptic liquid is driven in to a greater depth than by any other method, and (3) the process is very rapid, it being possible to impregnate many tons of timber in less than an hour in large cylinders.

A very ingenious method, invented by Boucherie, has been employed in France. This consists in attaching a pipe to the lower part of a log, so that the antiseptic solution employed, under a pressure of about one atmosphere, is gradually forced in to displace the natural fluids of the sap-wood of the tree. The pressure is obtained by elevating the reservoir of antiseptic. Sulphate of copper and chloride of zinc have been thus used, but since the log must be treated with the bark on (otherwise there is great loss at the surface) there are many drawbacks to this method—*e.g.* loss in conversion and carriage—except where whole trunks are employed and directly treated on the spot.

Part II.—The Timber of Dicotyledonous Trees.

I NOW pass to the consideration of the principal Timber trees of the British Empire and other parts of the world, commencing with those known to the forester generally as "Broad-leafed" trees—in contradistinction to the "Needle-leafed" trees of the Conifers—and to the botanist as Dicotyledons. These are the ordinary foliage-trees of the forests of all countries, and for the sake of practical convenience only, they will be taken more or less in order of their importance as met with in the various quarters of the globe, beginning with the trees of Europe, and passing on to those of America, Asia, etc., and especially those of our Colonies.

CHAPTER VIII.

EUROPEAN TIMBERS. THE OAK (*Quercus*).

THE Oak, regarded generally, is found to be very widely spread. It has been met with in Europe in about 35° N., and is known to extend to 60°, or over 25° of North latitude. Various species are also found in the north of Asia, North America, and in Africa.

The Oak exists in very great variety, and England produces two, if not three, distinct sub-species or varieties, in addition to numerous others, not native, but which are cultivated for ornamental purposes. The botanical names of those which are indigenous to this country are *Quercus Robur pedunculata*, *Quercus Robur sessiliflora*, and *Quercus pubescens*, or Durmast Oak.

In the former, which is our best species, the footstalks of the female flowers and acorns are long, while those of the leaves are short. In *Quercus sessiliflora* this order is reversed, the footstalks of the fruit being short and those of the leaves long; while the distinguishing character of *Quercus pubescens* consists in its having the under sides of the leaves somewhat downy, the footstalks of the fruit and leaves nearly resembling those of the *sessiliflora* variety. It is also peculiar to the leaves of the Durmast or pubescent species that they commonly hang longer on the tree than those of either of the others.

It is the prevailing opinion that the wood of *Quercus Robur pedunculata* is the best in quality, and that *Quercus*

Robur sessiliflora is slightly inferior to it; but, while coinciding generally in this opinion, I feel bound to admit that, during a long experience in working them, I have not been able to discover any important difference between the two varieties.

We find, indeed, the wood of the two species so closely resembling each other, that few surveyors are able to speak positively as to the identity of either. It is only by tracing the log from the first fall of the tree to the hands of the converter that we are able to say that the timber of the *sessiliflora* is a little less dense and compact in texture than that of the *pedunculata*.

The Durmast Oak is only sparingly met with, and is usually of inferior quality. Preference should therefore be given in all works of importance to the two species before mentioned; and in this there will be no difficulty, as they are easily obtainable.

It is fortunate that *Quercus Robur pedunculata*, which is believed to produce the best timber, is to be found in greater abundance than *Q. sessiliflora*; and it is greatly to be desired that in any future planting, care should be taken to perpetuate it, although as a commercial speculation *Q. sessiliflora* would probably yield the best return, as it generally attains a greater length of clear stem.

Very fine specimens of these long, clear stems of *Q. sessiliflora* are to be met with in abundance in the Forest of Dean, in Gloucestershire, where, upon a rocky subsoil, the Oak trees generally attain noble dimensions, with, however, this drawback—they are liable to the cup and the star-shake. Whether this is caused by the rocky nature of the soil, combined with the swaying to and fro of these tall trees by strong winds, or whether it is in some degree peculiar to the

species, is not easily determined. I incline, however, to the belief that these defects are less frequent in *Quercus Robur pedunculata*, whatever the situation or soil may be upon which they are grown.

There appears to be little difficulty in rearing the Oak tree; it thrives in almost any soil, except that which is boggy or peaty; but to bring it to the greatest perfection, it is preferable to have a rich loam with a deep subsoil. It will even spring up again from the old stool, or root, and without requiring any attention, produce, in time, one or more fine trees in place of that which was first cut down.

The following dimensions of nine Oak trees that were growing only a few years since (and possibly are so still) at Woburn Abbey Park, may be interesting, as showing the size they will attain upon a favourable soil. The particulars are taken from a small book, published in 1832, under the superintendence of the Society for the Diffusion of Useful Knowledge:—

TABLE V.

Oak Trees. No.	Height.	Circumference.
1	Stem 50 ft., measures at 3 ft. 6 in. from the ground	17 ft. 3 in.
,,	,, ,, ,, 20 ft. ,, ,,	14 ft.
2	,, 35 ft. ,, 4 ft. ,, ,,	17 ft. 9 in.
,,	,, ,, ,, 20 ft. ,, ,,	12 ft. 9 in.
3	,, 20 ft. ,, 4 ft. ,, ,,	13 ft. 0¼ in.
,,	,, ,, ,, 20 ft. ,, ,,	12 ft. 0⅓ in.
4	,, ,, 3 ft. ,, ,,	12 ft. 0½ in.
,,	,, ,, 66 ft. ,, ,,	8 ft. 0¼ in.
5	,, ,, 4 ft. ,, ,,	14 ft.
,,	,, ,, 56 ft. ,, ,,	9 ft. 0⅛ in.
6	,, ,, 3 ft. ,, ,,	14 ft. 4 in.
,,	,, ,, 34 ft. ,, ,,	12 ft. 6 in.
7	,, ,, 4 ft. ,, ,,	12 ft.
,,	,, ,, 50 ft. ,, ,,	8 ft. 0¼ in.
8	,, ,, 4 ft. ,, ,,	13 ft. 0½ in.
,,	,, ,, 50 ft. ,, ,,	8 ft. 0½ in.
9	,, ,, 3 ft. ,, ,,	13 ft. 0¼ in.
,,	,, ,, 48 ft. ,, ,,	8 ft. 0¾ in.

"It is stated that at the lowest estimate, the total quantity of timber in these nine trees amounts to 3,200 cubic feet of the very best quality for naval architecture, and that although they must be of great age, it is remarkable that no symptoms of decay appear in them. They are perfectly sound and free from blemish."

The characteristic properties of the British Oak are, upon the whole, so good, that it has long been accepted by practical men as a standard of quality and fitness for architectural purposes, and in the classification of all other hard and heavy woods in use in the royal dockyards, they are tabulated as "substitutes" for "Oak"; the individual species, differing from it either in kind or specific gravity, or in having some important property attached to it, being only specially noted in the specification for building a ship* whenever it is considered desirable to secure some particular element of lightness or strength, dissimilar to that of the standard.

The English Oak tree, if grown in sheltered situations or in forests, frequently reaches to a height of 70 to 100 feet, with a clear, straight stem of from 30 to 40 feet, and a circumference of 8 to 10 feet, and much larger specimens (though now only rarely to be met with) were formerly common. If grown in open and exposed situations, it is generally shorter, and frequently takes strange and eccentric forms, assuming a

* No wooden man-of-war has been built for our Navy for upwards of twenty years, nor are we in the least likely to revert to the building of such; but, although Oak is now so little used for ship-building in comparison with its demand when the above remarks were written, I have retained Mr. Laslett's words because his opinion applies to other uses to which this timber is applied. The case is somewhat different in the Mercantile Marine, and of the vessels on Lloyd's register about 10 per cent. of the British tonnage is of wood. This is still more the case with the Colonies, which, having more abundant material, build more wooden vessels than we do, though the ships themselves are of a less important commercial type.

somewhat curved and crooked shape; this, however, is one of its most valuable characteristics, as naturally curved timber is almost indispensable for wood ship-building. It is when grown under these conditions that it appears to attain its maximum of hardness, and is often found so gnarled and knotty that it is difficult to work.

The long, straight, fair-grown trees, which yield the largest proportion of useful wood, are most in request for the general purposes of the architect and engineer, but they are also fully appreciated by ship-builders, who employ them for beams, waterways, keelsons, etc.

Oak timber of the gnarled description, and having some figure in the grain, is in request for articles of furniture; and even when in a state of decay, or in its worst stage of "foxiness," the cabinet-maker prizes it for its deep-red colour, and works it up in a variety of ways.

The economical uses of Oak timber, and especially the English varieties of it, are, on account of its many valuable properties and freedom from excessive weight —the specific gravity being about ·597 to 1·024—so extensive that it would be impossible to enumerate the many useful purposes to which it is applied, while in wood ship-building it is invaluable, and, indeed, almost indispensable, as it is flexible enough to bear bending to the most curved and difficult parts in a ship's construction, without breaking.

The wood is light-brown in colour, hard, tough, and very strong; it does not splinter readily, and its solidity of character is such that it resists well the action of water. In seasoning it is apt to warp and shrink, although not to any considerable extent; consequently it cannot be used in a partially dried state without in-

curring some risk to the stability of the work; but when once its moisture is completely evaporated, few woods are liable to so little change, particularly when employed in situations where it is protected from the influence of moisture or draught. If subjected to alternations of wet and dry, it withstands the change better than most other woods; while, if kept wholly submerged, there is scarcely any limit to its endurance.

Oak timber has, however, one drawback. It contains a powerful pyroligneous acid, which prevents its general employment in immediate contact with iron, as the metal, whether used for fastenings or otherwise, is subjected to a rapid corrosive action, while the timber is also liable to suffer by waste and deterioration.

British Oak timber has, for ages past, been a most important article in ship-building in this country, and it is still used for this purpose to a very great extent, notwithstanding the present very general use of iron as a substitute for it.

It is only within the last few years that it has been felt that the quantity of Oak produced in England would soon be inadequate to meet the great and increasing demand for it, and that it was necessary efforts should be made to supplement it by the introduction of foreign Oaks and other hard woods for ship-building purposes.

To show this great necessity it will be sufficient to state, approximately, the store of ship-building timber which it was thought necessary to maintain at Woolwich Dockyard in the several quinquennial periods of the quarter-century ending in 1865.* It will, apart from the ordinary demands of the private trade, serve to illustrate

* This stock, I am informed, is now all gone, and very little Oak is now bought for the royal dockyards. The illustrative statement retained, therefore, is merely matter of history now.

in some degree how large must have been the supplies annually required for all the royal dockyards, taken collectively, in order to replace the ships that were worn-out or had become obsolete, and to keep the ships of the royal navy up to the strength called for by the times.

The store of timber maintained at Woolwich Dockyard suitable for ship-building was as follows, viz.:—

TABLE VI.

In the years	English Oak.	Foreign timber, or Substitutes for Oak.	Total.
	Loads.	Loads.	Loads.
1840	1,591	936	2,527
1845	1,029	2,196	3,945
1850	1,259	3,693	4,952
1855	1,868	4,596	6,464
1860	857	6,977	7,834
1865	5,490	14,077	19,567

The smallest quantity of English Oak at that yard at any one time within the thirty years ending in 1867 was 857 loads in 1860, and the largest 5,490 loads in 1865; while the smallest stock of foreign timber in store for use as substitutes for Oak was 936 in 1840, and the largest 16,771 loads in 1863. The smallest store of ship-building timber of all kinds held there during the same period was 2,356 loads in 1841, and the largest 21,012 loads in 1863.

The relative quantities of English Oak and its substitutes were kept up at all the yards, in proportion to the magnitude of the several naval establishments, and in 1860 there was the large quantity of 35,800 loads in the various stores, suitable for ship-building, exclusive of Elm, Fir, and Pine timber and plank; and this was very largely supplemented by later deliveries.

CHAPTER IX.

EUROPEAN TIMBERS—(*Continued*).

EXPERIMENTS UPON THE TRANSVERSE STRENGTH OF BRITISH OAK.

BRITISH Oak timber being, as before stated, generally recognised as the standard of quality, the greatest possible care was taken in preparing the specimens of the prescribed dimensions—2″ × 2″ × 84″—for the experiments to test its strength; further, the deflections under a weight of 390 lbs., as also that at the crisis of breaking, and the exact breaking weight each piece bore, were all taken, the results being shown in the tables which follow. It is hoped, therefore, that a sufficient guide is thus afforded, not only for comparing its strength with other woods, but also for determining the scantling required for architectural purposes:—

TABLE VII.—ENGLISH OAK.
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific Gravity.
	Inches.	Inch.	Inches.	lbs.	
1	3·500	·200	5·250	590	905
2	3·125	·312	8·500	825	682
3	3·250	·125	11·000	1,002	708
4	3·250	·125	6·500	797	725
5	3·500	·250	7·000	804	720
6	3·625	·125	5·875	637	670
Total .	20·250	1·137	44·125	4,655	4410
Average	3·375	·189	7·354	776	735

REMARKS.—Nos. 1 and 4 broke with a moderate length of fracture; 2, 5, and 6 with 9 to 15 inches and splinters in fracture. No. 3 was not completely broken asunder.

TABLE VIII.—ENGLISH OAK.

Transverse Experiments.—2nd Example.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific Gravity.
	Inch.	Inch.	Inches.	lbs.	
7	1·625	·125	4·125	674	780
8	1·625	·250	5·250	837	753
9	1·500	·187	5·000	824	770
10	1·625	·125	9·500	977	1005
11	1·750	·000	9·250	882	1003
12	1·500	·000	8·750	827	1002
Total .	9·625	·687	41·875	5,021	5313
Average	1·604	·114	6·979	837	886

REMARKS.—No. 7 broke short; 8 and 12 with 7 to 13 inches length of fracture; 9, 10, and 11 with 15 inches scarph-like splintery fracture.

The Tables VII. and VIII. each refer to parcels of six pieces, which were taken from trees of good average quality and size, moderately seasoned, and fit to be applied to architectural works, the specific gravity varying from 670 to 1005. Of the twelve pieces tested, the elasticity of two, after the weight of 390 lbs. was removed, was perfect. One piece recovered its straightness to within ·312 inch, while of the remainder, nine in number, the elasticity was in all something better, though not quite perfect.

The deflections varied under this weight of 390 lbs. from 1·500 to 3·625 inches, the ultimate deflections at the crisis of breaking varying from 4·125 to 11·00 inches; while the breaking weight varied from 590 to 1,005 lbs., the average results being 201·58 lbs. on the square inch.

Taking the mean of the figures in the Tables VII. and VIII., we have a deflection of 2·489 inches with 390 lbs.; but only ·151 inch after the weight had been removed,

the ultimate deflection at the time of breaking being 7·166 inches, the breaking weight 806·83 lbs., and the specific gravity 810. Further results may be got by applying the formulæ used by Professor Barlow, viz., $E = \frac{l^3 w}{4 a d^3 \delta}$; l = length, a = width, d = depth, and δ = deflection.

* It should be borne in mind that in determining the scantlings to be employed, there are to be taken into account the possible chance of a short or twisted grain, a spiral turn of the fibre, knots, faulty or otherwise, and the risk which the practical builder must always run of having some defects hidden beyond the possibility of detection in, perhaps, his best-looking pieces. It would, therefore, be obviously unsafe to subject them to anything like the strain which the ascertained average strength of the specimens tested would seem to warrant charging them with.

Considering the importance of this, it was determined to extend the experiments by testing a series of pieces taken from a longitudinal section cut through the centre breadth of a very fine-looking Oak tree. In setting out the specimens, the centre piece containing the pith and a very small heart-shake, was allowed to drop out as being of little or no value for the trial.

The six pieces cut from one side of the centre or pith of this tree, came out with a long, clean, straight grain, as the appearance of the log had promised; but the six taken from the opposite side were not nearly so good, the grain being in each a little waved or twisted,

* It should be noted that Laslett gives the total length of his specimens, instead of the length between supports, and consequently his results are not in accordance with those of others. The reader should consult special works on this part of the subject. (See p. 72.)

and the fibre of no great length. Some had small pin-like knots in them, and the surface of the plank being dotted over with these, it presented a mottled appearance, somewhat resembling Bird's-eye Maple.

The specimens are numbered from the centre or pith of the tree outwards—1 to 6 and 1′ to 6′ in column 8. The results are as follow, viz.:—

TABLE IX.

Transverse Experiments.—3rd Example.

—	Number of the specimen.	Deflection. With the apparatus weighing 390 lbs.	Deflection. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Direct cohesion on the square inch.	Number of the specimen in the tree.
The mean of 1′ to 6′	...	Inches. 3·25	Inches. 3·95	lbs. 407	867	lbs.	
ENGLISH OAK.	13	3·75	3·75	390	836	...	6′
	14	3·75	3·75	400	866	...	5′
	15	...	3·50	390	868	...	4′
	16	...	...	390	865	...	3′
	17	...	3·75	390	860	...	2′
	18	2·25	5·00	480	910	...	1′
	19	2·00	7·00	740	900	5,320	1
	20	2·00	4·50	630	900	4,400	2
	21	2·25	5·00	620	854	4,200	3
	22	3·50	4·50	470	864	4,340	4
	23	3·75	5·00	480	838	2,520	5
	24	4·00	4·50	430	791	2,240	6
The mean of 1 to 6 .		2·916	5·10	562	858	3,837	...
The mean of the whole		3·083	4·525	484	862·5	...	...

REMARKS.—Nos. 13 to 17 inclusive broke very short; 18 and 19 were nearly alike, and had scarph-shaped fractures 10 inches in length; 20 and 21 had long splintery fractures; 22 to 24 inclusive broke short to ⅙th the depth, then long fractures.

In the specimens marked 1 to 6, the greatest strength was possessed by the piece taken from close to the centre of the log, which comprised the oldest and densest annual layers, while No. 6, which was farthest removed from it, and contained the most recently perfected dura-

men, proved to be the weakest, the respective breaking weights showing a difference of nearly 42 per cent.

Turning to the specimens marked 1′ to 6′, taken from the other side of the tree, we find a similar result as regards the inner and the outer layers, the greatest strength being again near to the centre of the tree; No. 5′, however, bearing the next greatest strain. The pieces Nos. 2′, 3′, 4′, and 6′, each broke as the weight of the scale was applied, and are therefore of little value.

We may gather, however, from the trial, that from the centre to the circumference of this tree there was clearly a diminution of strength, which, although not quite proportionate to the decrease observed in the specific gravity of the several pieces, is yet in some degree approximate to it.

I infer from this that the tree had not reached maturity when it was cut down, and that it was still in the prime of life. Had it been otherwise, we should have expected, when viewed by the light of other experiments, to find that the point of density and greatest strength would lie in the piece marked 4, or even farther removed from the centre.

There can be very little doubt that the wood of this tree, if used in its greatest bulk, or in any large scantlings, would have been found to possess fully the average strength of Oak timber, and that it was only weak in certain parts, as discovered on trial when cut into strips of 2 inches square. There still remains, however, the fact that in a fine tree, sound and apparently free from defect, nearly the whole of one side was found to be faulty, while the other half proved to be inferior in strength to the specimens of average quality noticed in the Tables VII. and VIII., the mean breaking weight of the best side being 562 lbs., as com-

pared with 776 lbs. in Table VII., and 837 lbs. in Table VIII. (mean = 806·5), the weaker side not affording any figures by which it could be compared with previous experiments.

The deflections of a few specimens, under given weights and with various bearings, are shown in the following tables:—

DEFLECTIONS: ENGLISH OAK.

TABLE X.

Specimens: depth, 1½ inch; breadth, 2 inches; length, 84 inches; weighted with 300 lbs.

Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
25	795	·375	·750	1·187	2·500
26	785	·500	·875	1·750	2·750
27	782	·375	·750	1·625	2·500
28	775	·375	·750	1·500	2·625
Total . .	3·137	1·625	3·125	6·062	10·375
Average .	·784	·406	·781	1·515	2·593

TABLE XI.

Specimens as in Table X., weighted with 400 lbs.

Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
29	795	·625	1·00	2·00	3·625
30	785	·687	1·125	2·25	3·937
31	782	·437	1·000	2·25	3·562
32	775	·625	1·000	2·00	3·250
Total . .	3·137	2·374	4·125	8·50	14·374
Average .	·784	·593	1·031	2·125	3·593

TABLE XII.

Specimens: depth, 2 inches; breadth, 1½ inch; length, 84 inches; weighted with 300 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
33	795	·312	·625	1·063	1·625
34	785	·250	·500	·875	1·500
35	782	·187	·563	·937	1·562
36	775	·250	·437	·875	1·562
Total . .	3·137	1·000	2·125	3·750	6·249
Average .	·784	·25	·531	·937	1·562

TABLE XIII.

Specimens as in Table XII., weighted with 400 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
37	795	·375	·625	1·250	2·125
38	785	·312	·625	1·125	2·000
39	782	·250	·750	1·187	2·125
40	775	·437	·625	1·312	2·000
Total . .	3·137	1·374	2·625	4·874	8·250
Average .	·784	·343	·656	1·218	2·062

CHAPTER X.

EUROPEAN TIMBERS—(*Continued*).

ON THE TENSILE STRENGTH, OR DIRECT COHESION, AND STRENGTH UNDER COMPRESSION OF BRITISH OAK.

THE tensile experiments are somewhat difficult to carry out, and therefore only specimens Nos. 1 to 6, Table IX., were tested from the log referred to at page 102. They varied from 2,240 to 5,320 lbs., giving a mean strength of 3,837 lbs. to the square inch, the wood next to the pith or centre proving to be the strongest, as with the transverse test. The gradations of strength, taking No. 1 as unity or 1·00, give No. 2 as ·82; No. 3, ·785; No. 4, ·81; No. 5, ·475; and No. 6, ·42, the tensile strength of the inner wood of this tree being therefore about 58 per cent. greater than the outer.

Instances of weakness, both transversely and tensilely, similar to those which are given in Table IX., are not unfrequent, and may occur, as before stated, in good-looking specimens of any species of timber: and this, again, serves to show that it would be unsafe to arrange the various parts of any construction according to the highest calculated strength of any timber to be employed.

Further tensile experiments were made on six specimens of British Oak saved from the pieces experimented

upon, and referred to in Tables VII. and VIII. They appear to be of better quality than those referred to in Table IX. The following are the results :—

TABLE XIV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the pieces broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
43	2 x 2 x 30	1003	35,560	8,890
44	2 x 2 x 30	1005	31,360	7,840
45	2 x 2 x 30	1002	33,600	8,400
46	2 x 2 x 30	905	33,040	8,260
47	2 x 2 x 30	720	24,640	6,160
48	2 x 2 x 30	725	23,520	5,880
Total . .	...	5360	181,720	45,430
Average .	...	893	30,287	7,571

Very little appears to be known of the amount of resistance offered by British Oak to a crushing force, when applied in the direction of its fibres. Some experiments of the kind have, it is true, been made, both in this and in other countries, but the results, as published, are far from being satisfactory, inasmuch as they vary to a great extent, as between author and author, and afford no reliable measure of the strain to which a pillar or column can be safely loaded.

The difficulty of carrying out these experiments is indeed so great, and withal so extremely tedious, that it is no matter of surprise more has not been done in this direction. I have, therefore, with the view of supplying a want long felt, availed myself of every opportunity to extend this important inquiry, by experimenting not only upon English Oak timber, but upon

perhaps a greater variety of woods than has ever before been attempted.

The experiments on the vertical strength of British Oak are given in Tables XV. to XXII. inclusive.

TABLE XV.

Cubes of Unseasoned British Oak. Specific gravity, 966.
Vertical or crushing experiments.

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
49—52	2·750	7·000	20·000	33·750
53—56	2·500	8·000	19·375	31·875
57—60	2·000	9·500	20·125	33·125
61—64	2·500	8·500	19·625	32·875
65—68	2·250	8·125	20·500	33·125
69—72	2·375	9·250	20·125	33·500
Total . .	14·375	50·375	119·750	198·250
Average .	2·396	8·396	19·958	33·041
Do. per in.	2·396	2·099	2·217	2·064

TABLE XVI.

Cubes of Seasoned British Oak. Specific gravity, 740.
Vertical or crushing experiments.

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
73—76	3·750	13·000	28·750	50·875
77—80	3·500	12·500	29·750	50·125
81—84	3·375	14·375	29·125	49·875
85—88	3·625	14·000	28·500	50·625
89—92	3·500	13·875	29·125	49·875
93—96	3·625	14·125	28·875	51·125
Total . .	21·375	81·875	174·125	302·500
Average .	3·562	13·646	29·021	50·417
Do. per in.	3·562	3·411	3·225	3·151

TABLE XVII.

Vertical or Crushing Experiments on British Oak, with 4 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square in .h.
	Inches.		Tons.	Tons.
97	2 × 2 × 1	740	13·500	3·375
98	,, ,, 2	,,	13·625	3·406
99	,, ,, 3	,,	13·875	3·469
100	,, ,, 4	,,	14·000	3·500
101	,, ,, 5	,,	15·750	3·937
102	,, ,, 6	,,	14·875	3·719
103	,, ,, 7	,,	14·750	3·687
104	,, ,, 8	,,	14·500	3·625
105	,, ,, 9	,,	15·000	3·750
106	,, ,, 10	,,	slipped	—
107	,, ,, 11	,,	14·750	3·687
108	,, ,, 12	720	13·750	3·437
109	,, ,, 18	,,	11·000	2·750
110	,, ,, 24	,,	10·500	2·625
111	,, ,, 30	734	9·750	2·437

NOTE.—Nos. 97 to 107 (inclusive) were cut from one piece of timber, Nos. 108 to 10 were cut from another, and No. 111 from a third piece.

TABLE XVIII.

Vertical or Crushing Experiments on British Oak, with 9 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
112	3 × 3 × 8	912	15·50	1·722
113	,, ,, 9	981	16·125	1·792
114	,, ,, 10	960	16·00	1·777
115	,, ,, 11	943	16·50	1·833
116	,, ,, 12	928	14·75	1·639
117	,, ,, 13	901	13·50	1·500
118	,, ,, 14	891	14·00	1·555
119	,, ,, 15	883	15·00	1·666
120	,, ,, 16	900	15·00	1·666
121	,, ,, 17	768	23·50	2·611
122	,, ,, 18	789	22·00	2·444

NOTE.—Nos. 112 to 120 (inclusive) were cut from a piece of Oak timber that had een four years in store—it was not even then well seasoned; Nos. 121 and 122 were of etter seasoned timber.

TABLE XIX.

Vertical or Crushing Experiments on British Oak, with 16 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
123	4 × 4 × 15	958	25·50	1·600
124	,, ,, 16	972	25·25	1·578
125	,, ,, 17	934	27·00	1·687
126	,, ,, 18	930	27·50	1·719
127	,, ,, 19	932	28·25	1·762
128	,, ,, 20	972	28·25	1·762
129	,, ,, 21	946	28·00	1·750
130	,, ,, 22	932	26·00	1·625
131	,, ,, 23	921	23·50	1·470
132	,, ,, 24	1·003	30·00	1·875

TABLE XX.

Vertical or Crushing Experiments on British Oak, with 9 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
133	3 × 3 × 8	696	25·25	2·805
134	,, ,, 9	597	21·00	2·333
135	,, ,, 10	742	20·25	2·250

NOTE.—These were respectively Nos. 115, 118, and 121 of Table XVIII., shortened, and further seasoned.

TABLE XXI.

Vertical or Crushing Experiments on British Oak, with 16 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
136	4×4×10	713	34·875	2·179
137	,, ,, 11	658	33·750	2·110
138	,, ,, 12	639	32·000	2·000
139	,, ,, 13	665	29·500	1·843
140	,, ,, 14	752	31·250	1·953
141	,, ,, 15	742	28·500	1·781
142	,, ,, 16	688	40·750	2·517

NOTE.—These were respectively Nos. 132, 123, 125, 124, 127, 129, and 130 of Table ‹IX., shortened after the first experiments upon them, and further seasoned before the econd trial.

TABLE XXII.

Vertical or Crushing Experiments on British Oak; sundry scantlings.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
143	3 × 3 × 2	820	32·125	3·569
144	4 × 4 × 2	822	53·125	3·320
145	6 × 6 × 12	864	131·000	3·640
146	,, ,, 18	926	154·000	4·277
147	,, ,, 24	822	122·200	3·394
148	,, ,, 36	888	122·200	3·394
149	9 × 9 × 12	1·024	223·600	2·760
150	9′× 9′× 15	918	247·800	2·898
151	,, ,, 18	889	244·800	2·860
152	,, ,, 21	883	247·000	2·887
153	9′×10′× 15	904	397·000	4·175
154	10′×11 × 18	794	307·000	2·722
155	,, ,, 21	819	327·800	2·907
156	9′×10′× 24	905	307·000	3·239

In these tables are recorded the results of 108 experiments on the crushing strains applied to specimens of English Oak timber, varying from small pieces with only 1 inch of base, and 1 inch in height, carrying 7,978 lbs., to larger pieces with 110 inches of base, and 21 inches in height, carrying 734,272 lbs., or 327 tons 16 cwt., before breaking. The intermediate sizes include some pieces with 36 inches of base and 36 inches in height, this being the greatest length upon which I have been able to bring the crushing force to bear.

It is to be regretted that these experiments could only be carried on with pieces of inconsiderable length, owing to the difficulty experienced in keeping the centres perfectly straight with the line of pressure. Still, enough has, I hope, been done to afford a fair guide for determining the scantlings for pillars to beams, etc., although, perhaps, there is not even yet sufficient data to construct a formula upon.

M. Rondelet ascertained that it took a force of 5,000 to 6,000 lbs. to crush a piece of Oak having 1 inch of base; and Mr. Rennie gives 3,860 lbs. as the force required to crush a similar piece 1 inch in height. These two statements vary considerably from each other, and also from my own experience, inasmuch as I found it required a force of 7,978 lbs., or 3·562 tons weight, to crush a 1-inch cube of seasoned Oak; *vide* Table XVI.

In a trial, however, of six pieces of unseasoned Oak of the same dimensions, it was found that it took upon an average only 5,367 lbs., or 2·396 tons—one piece requiring only 4,480 lbs., or 2 tons, to crush it; *vide* Table XV.

The experiments upon seasoned cubes of Oak, of 2,

3, and 4 inches (Table XVI.) show that the force required to crush them was, severally, 7,640 lbs., 7,224 lbs., and 7,058 lbs., per square inch of base, which, if compared with 7,978 lbs. on the one-inch cube of the same seasoned wood, shows an apparent diminution of strength in each of the next larger sizes; the average force required to crush the complete parcel of four sets of cubes being 7,475 lbs. The average strength of the unseasoned pieces of the same dimensions only 4,915 lbs. to the square inch of base.

There is yet another description of test to be noticed, namely, that for ascertaining the elongation of the fibres under certain strains. The experiment was made in one of the royal dockyards upon two pieces of English Oak, each 2 x 2 x 48 inches, and very carefully conducted—note being taken of the elongation in a length of 3 feet; the mean results were found to be as follows, viz. :—

TABLE XXIII.

With the weight of	2	3	4	5	6	7	tons.
The elongation was	·0	·03125	·04617	·07812	·1250	·15625	ins.
With the weight of	8	9	10	11	12	...	tons.
The elongation was	·19375	·23437	·2500	·2500	·3125	...	ins.

CHAPTER XI.

EUROPEAN TIMBERS—(*Continued*).

ON THE FELLING OF OAK IN SPRING AND WINTER.

THE bark of the Oak tree, or, more strictly speaking, the cortical tissues under the true bark, contains a substance called tannin, which is of considerable value, and is used in the preparation of leather. Therefore, in order to secure this tannin in its greatest quantity, it is the practice to fell, or cut down, the trees in the spring of the year, when the sap is rising ; moreover, the bark is more easily removed in the spring. Under other circumstances, the trees would have been cut in the winter, while the sap was down and in a quiescent state —a period which has been almost universally recognised as the best for felling, as it ensures a better quality, and is conducive to the greater durability of the timber. This is because the walls of the wood-elements are then thoroughly lignified and hardened, there is less water in the wood, and the decomposable substances are less abundant and less in a soluble form conducive to rot. The value of the bark, however, generally overrides this consideration, since, although the weight in proportion to the contents of the timber will vary according to circumstances of growth, it is always thought profitable to save it, and,

viewed under the commercial aspect, it is not likely to be disregarded.

The quantity of tannin contained in the bark of the Oak, as ascertained by Sir Humphry Davy, varies as follows, viz.: In Coppice Oak it is 32; middle sized, 29; and Oak cut in the autumn, 21 per cent.

The timber and bark merchants variously estimate the quantity of bark proportionate to the contents of the timber; and no doubt there is a very considerable difference in the weight afforded by trees of equal ages, whether grown in forests or in open situations. Mr. Monteith states, in his "Planter's Guide," that—

An Oak 40 years old yields, for every cubic foot of timber	9 lbs. to 12 lbs. of bark.
And if 80 to 100 years old yields, for every cubic foot of timber	10 lbs. to 16 lbs. ,,

The question of the propriety of felling in the winter in preference to any other season is of considerable importance, and its bearing upon the durability or otherwise of the timber may be gathered from the following particulars, taken from a "Treatise on Dry Rot," by Ambrose Bowden. He states that—

"The *Sovereign of the Seas*, built at Woolwich in 1635, was constructed of timber barked in the spring and felled in the succeeding winter, a strong conviction existing that such timber was superior to any other in point of durability. Forty-seven years later this ship was pulled to pieces and rebuilt, and the greater part of the materials were found to be in sufficiently good condition for re-employment.

"The *Royal William*, built at Portsmouth in 1715 to 1719, after being slightly repaired at three different times, was finally taken to pieces in August, 1813, after a service of ninety-four years. The extreme durability

of this ship attracted much attention at the time, and it was believed that, having been built in close proximity to the New Forest, only winter-felled timber had been used in her construction. This is said to be borne out by the fact that the authorities at Portsmouth, about 1717 or 1718, offered, as an encouragement for the delivery of winter-felled Oak timber to that yard, an addition of* £5 per cent. to the contractor to compensate him for the loss of the bark. The state of the materials when the ship was taken to pieces confirmed the conjecture which had been then formed, as the iron fastenings, above the water-line, were in general good, proving the absence of acrid juices in the timber.

"In the year 1755, Mr. Barnard, of Deptford, contracted to build a sixty-gun ship, named the *Achilles*, for His Majesty's service. She was completed in 1757, and taken to pieces in 1784. It was not known that any peculiar circumstances attended the construction of this ship, until Mr. Barnard was summoned to attend a Committee appointed by the House of Commons, in March, 1771, to consider how His Majesty's navy might be better supplied with timber. He then gave it as his opinion that the method to be observed in felling timber should be by barking in the spring, and not to fell it until the succeeding winter, and added that he built the *Achilles*, man-of-war, in 1757, of timber felled in that manner.

"The *Montague*, launched in 1779, was built of winter-felled timber, and its superiority is forcibly attested by the fact that she had only one frame-timber

* A much higher premium than £5 per cent. in addition to the contract price of spring-felled Oak timber was offered and paid by the Government a few years since for winter-felled Oak, without, however, being able to obtain more than a fraction of the quantity required for the royal dockyards.

shifted, from the time she was built up to 1803, when she was repaired. Mention is also made of this ship being in active service and in good condition in 1815; that is, thirty-six years after she was launched. It was thought there was a striking coincidence between the durability of this ship and that of the *Royal William*, affording a strong presumption that they were both built on the same principles.

"The *Hawke* sloop was built in 1793, one half of timber barked in the spring and felled in the winter, and the other half of timber felled at the usual time in spring. Ten years later she was in such a general state of decay that she was taken to pieces, no difference being then observable in the condition of her several timbers."

"At first view," Mr. Bowden observes, "this experiment appears to decide the fate of the system; but it must be remarked that the timber was barked standing in the spring of 1787, and not felled until the autumn of 1790, a period of three and a half years; and further, that if we were to inquire into the probable duration of such timber, we might discover, perhaps, that it is in an inverse ratio to the time the trees may stand after being barked; and therefore, this ship was in precisely the same state at the end of ten years as we might reasonably have expected."

CHAPTER XII.

EUROPEAN TIMBERS—(*Continued*).

BRITISH OAK.—CONTRACT SPECIFICATION.

THE British Oak tree affords logs that meet the following specification for the navy contracts, viz.:—*

Timber sided; or if rough, that will side—

20 inches and upwards, the shortest length being 26 feet.				
20½ ,,	to 19 inches,	,,	,,	24 ,,
18½ ,,	,, 17 ,,	,,	,,	20 ,,
16½ ,,	,, 15 ,,	,,	,,	16 ,,
14½ ,,	,, 13 ,,	,,	,,	14 ,,
12½ ,,	,, 11 ,,	,,	,,	12 ,,
10½ ,,	,, 9 ,,	,,	,,	10 ,,

the quantities of each class or siding varying according to the requirements of the dockyards.

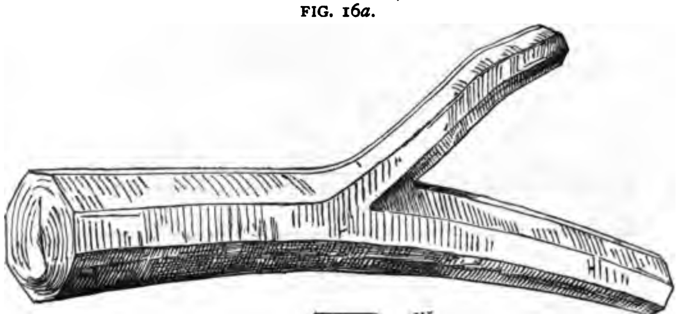
For the rough timber (Fig. 16, *a* and *b*) it is generally agreed that the price is to be, for each log measuring—

250 cub. ft. and upwards, rough contents, per load of 50 cub. ft. £				
249 ,,	to 200 cub. ft.	,,	,,	
199 ,,	,, 150 ,,	,,	,,	
149 ,,	,, 100 ,,	,,	,,	
99 ,,	,, 50 ,,	,,	,,	
49 ,,	,, 25 ,,	,,	,,	
	Under 25 ,,	,,	,,	

* It may be remarked that I have retained these illustrative specifications, not because they have any importance now as regards the navy, but because they may be of use to private individuals in purchasing.

the conditions being that the measurement of rough timber for payment is to be regulated by the stops or joggles. Every piece to be measured for contents by calliper measurement, as far as the spire will hold 12 inches in diameter. No tops to be received, except the spire and such other top or limb as may be grown on the main piece, of a substance and length to admit of being converted with it. Such other top or limb

FIG. 16*a*.



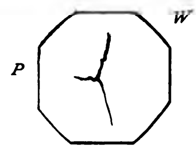


FIG. 16*b*.

will be measured for contents as far as it will hold 12 inches in diameter. If, however, the professional officers of the yards are of opinion that the conversion of the main piece will be improved thereby, tops, including the spire, will be measured for contents as far as they will hold 9 inches in diameter; but, in such case, two-thirds only of the contents below 12 inches in diameter will be added to the other contents of the piece for payment. All the rough timber to be so hewn or squared that no part of the surface or square

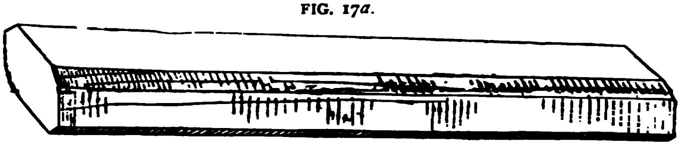
shall be less than one-fourth of the diameter of the piece.

For the sided timber (Fig. 17),* it is also agreed that the price is to be, for each log measuring—

120 cub. ft. and upwards, sided contents, per load of 50 cub. ft. £					
119	,,	to 100 ft.	,,	,,	
99	,,	,, 80 ,,	,,	,,	
79	,,	,, 60 ,,	,,	,,	
59	,,	,, 40 ,,	,,	,,	
39	,,	,, 20 ,,	,,	,,	
		Under 20 ,,	,,	,,	

the conditions being that in computing the measurement

FIG. 17*a*.



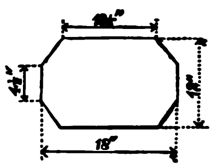


FIG. 17*b*.

for payment of sided timber, no quarter-inches to be allowed in the sidings. All the timber to be so sided that, between the wanes,† at half the length of the piece, there shall not be less than the siding with one-eighth

* It has been found in practice that a fairly grown cylindrically-shaped British Oak tree of

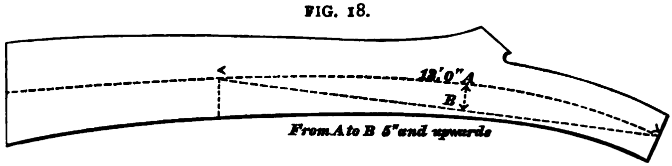
30 inches calliper will yield sided timber of about 21 inches.					
24 ,,	,,	,,	,,	18¼ ,,	
18 ,,	,,	,,	,,	12¼ ,,	

and that generally about two-thirds of the calliper of the rough tree is the siding to be obtained from it.

† Wane is the natural rounded edge of the log, *W*, Fig. 16*b*.

added thereto; to be fairly sided from end to end, parallel, and to be measured for contents as far as it holds, at the top end, on each side, between the wanes, three-fourths of the siding of the piece. The pane* at the top is to determine the length of the piece; but if the length of the sides be not equal, the mean is to be taken. The timber to be so hewn upon the moulding edges that the surface of the square shall not be less than one-fourth the diameter of the piece. The timber to be measured for contents at the middle of the length,

FIG. 18.



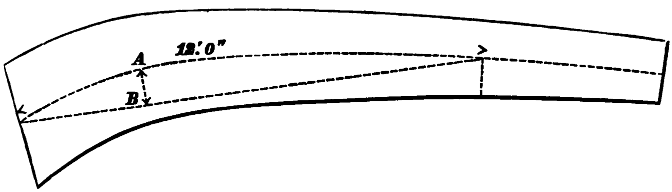


FIG. 19.

when fairly grown from end to end, but if otherwise, it will be regulated by the stops or joggles. Such timber as has length beyond the prescribed proportion of pane, being compass timber, and the additional length aiding the conversion, or such as shall be *bonâ fide* convertible for a beam piece, to be received at the discretion of the officers who are to determine the length; two-thirds of the additional length to be measured for the cubic contents.

It is, of course, understood that the wants of the

* Pane is the hewn or sawn surface of the log, *P*, Fig. 16*b*.

private trade are as well met as those of the royal navy, nothing being required of the navy specification other than is afforded by the ordinary growth of the tree.

Thick-stuff and plank is supplied to the navy according to the following specification:—

Thickness.	Shortest length.	To average in length at least	Breadth between the sap at 24 ft.	To be measured as far as it holds between the sap.	REMARKS.
Inches.	Feet.	Feet.	Inches.	Inches.	
10			11	8	
9			,,	,,	
8			,,	,,	Thick stuff, 4½ in. and upwards, is measured in cubic feet.
7			9	7	
6	24		,,	,,	
5		28	,,	,,	
4½			,,	,,	
4			8	6	
3½			,,	,,	Plank, 4 to 2 in. inclusive, is measured in superficial feet of its thickness.
3			7*	,,	
2½	20		,,	,,	
2			,,	,,	

* At 20 feet.

All the thick-stuff and plank to be cut straight, or nearly so, and of parallel thickness, and to be measured for breadth at the middle, or half the length, taking in half the wanes, provided the breadth, clear of sap, is within two inches of the breadth at which it is to be received; but no thick-stuff the breadth of which in the middle is less than 11 inches or more than 18 inches, and no plank of 4, 3½, and 3 inches, less than 9 inches or more than 15 inches, and none of 2½ and 2 inches less than 8 or more than 15 inches, clear of sap at half the length, is to be received.

All the timber, thick-stuff, and plank to be fresh-cut, good, sound, merchantable, well conditioned, and in every respect fit for Her Majesty's service.

CHAPTER XIII.

EUROPEAN TIMBERS—(*Continued*).

FRENCH OAK (*Quercus Robur*).

THE Oak timber of the north-western provinces of France, and especially of Brittany and Normandy, so closely resembles British Oak timber in colour, quality, texture, and general characteristics, that a description of one will as nearly as possible serve for the other. It is therefore, I think, fairly entitled to the first notice after that which has been adopted as our standard.

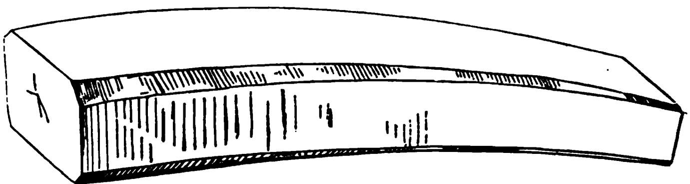
The French Government formerly claimed the right of first selection of this description of timber, and drew nearly all their supplies from the western districts, for the use of their own dockyards, the landed proprietors and merchants not being free to offer it on the market until the full requirements of the French navy were met. Consequently, but little, if any, of good quality was left for exportation after the demands of the private trade of that country were satisfied.

The first sample shipped to the London market after the relaxation of the French laws bearing upon it (about the year 1860) enabled the British Government to give it a trial in ship-building; and as this proved

to be satisfactory, a contract was soon after made with a London merchant for a supply to the several dockyards in England.

French Oak, until about the time I am speaking of, was looked upon with some disfavour in this country, and thought to be generally inferior in quality to the British Oak; but this opinion was probably formed from very unfavourable specimens, there being certain localities in France, as there are in most other countries, where the trees do not attain any degree of excellence,

FIG. 20*a*.



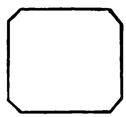


FIG. 20*b*.

and also from the fact that the best timber had been first selected and retained by the French Government.

Figs. 20*a* and 20*b* show the method of hewing the French Oak, whereby all the square wood that could be obtained is preserved, by simply following the natural taper or growth of tree, and, by so doing, there can be little, if any, disadvantage, since, the measurements being taken, as in English timber, at the middle, or half the length of the log, the buyer would receive and pay for the correct quantity contained in it.

French Oak is equal to the English in point of durability, and there is yet to be carried to its credit the fact that experiments prove it to be equally strong,

tough, and elastic. It is also in its favour that it shrinks only moderately in seasoning, and rends or splits somewhat less than the English Oak during that process.

That it is suitable and fit for all the purposes to which English Oak is applied, in ship-building or other works of construction, there is no reason to doubt; and, except that the timber procured from the north-west of France is generally smaller, shorter, and has a more tapering form than the English Oak timber tree, there is no appreciable difference in them, and in a manufactured state the cleverest expert could not tell one from the other.

The experiments made on French Oak (Tables XXIV., XXV., and XXVI.) are perhaps sufficient to show its relative merits as compared with our standard. French is classed with English Oak at Lloyd's, for employment in ship-building.

TABLE XXIV.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·50	·00	4·35	720	966
2	1·35	·05	7·00	930	977
3	1·50	·05	6·05	901	983
4	1·55	·10	5·50	895	992
5	1·65	·00	7·00	915	979
6	1·35	·05	6·10	904	962
Total . .	8·90	·25	36·00	5,265	5859
Average .	1·483	·041	6·00	877·5	976·5
The average of six other specimens, of equal quality to the above, gave—					
7—12	1·583	·125	7·583	831·	1082
The mean of the whole—					
	1·533	·083	6·791	854	1029·5

REMARKS.—All the specimens broke with a fibrous fracture fully 10 inches in length.

TABLE XXV.

Tensile Experiments.

Number of the specimen.	Dimension of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
13	2 × 2 × 30	966	21,280	5,320
14		979	40,040	10,010
15		983	39,208	9,802
16		962	27,432	6,858
17		977	33,460	8,365
18		992	33,040	8,260
Total . .	...	5859	194,460	48,615
Average .	...	976·5	32,410	8,102

TABLE XXVI.

Vertical Experiments on cubes of 2 inches.

No. 19.	No. 20.	No. 21.	No. 22.	No. 23.	No. 24.	Total tons.	Average tons.
Crushed with	Crushed with	Crushed with	Crushed with	Crushed with	Crushed with		
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.		
12·500	14·000	14·125	14·875	14·750	14·875	85·125	14·187
*3·125	3·500	3·531	3·719	3·687	3·719	14·187	3·547

* On 1 square inch.

REMARKS.—These cubes were in about the same seasoned condition as the English Oak, Table XVI.

CHAPTER XIV.

EUROPEAN TIMBERS—(*Continued*).

ITALIAN OAK (*Quercus*).

THERE are several varieties of very valuable oak trees spread over the whole length of the Italian peninsula, the island of Sicily, and also in the island of Sardinia, which in form and quality differ but slightly one from the other.

Botanists might say they were all of erect growth, yet they very rarely attain a perfectly upright position, as, owing to their naturally curved and crooked form of stem, they must necessarily be a little, more or less, inclined to the horizon. They appear generally to attain at least moderate dimensions; but, judging from those imported into this country, their best specimens are inferior in size to many of our British Oak trees.

The following forms of Italian Oak, viz., *Quercus Robur*, and its variety *Q. Æsculus*, *Q. pyrenaica* (the Pyrenean Oak), are the best in quality. There are also the *Q. cerris* (usually known as the Turkey Oak), *Q. Ilex*, *Q. Suber* (cork oak), and one or two others which are not generally thought to be equal to those first mentioned. Some of these may, nevertheless, occasionally compare favourably with them, especially when they are found at a moderate elevation, or on the mountain sides.

The wood of Italian Oak is brown in colour, hard, horny, tough, strong, less elastic and slightly heavier than the English Oak, and is, on account of its extreme hardness, more difficult to work. In seasoning it is very apt to split and leave deep shakes on the exterior of the log, which are detrimental to its value for general purposes; but, viewed as to its form and properties, it is employed in preference to most other Oaks for the frame of a ship. It may also be used in any work of construction where strength and durability are important, if care be taken to protect it, by planks or otherwise, from exposure.

Owing to its characteristic defect of shakes in seasoning, Italian Oak is unfit for conversion into planks, or boards, or into almost any small scantlings; and its introduction into this country (about the year 1820) was not with the view to its general employment, but solely to supplement the supply of British Oak timber, which was then scarce, and seemed likely to be insufficient in quantity to meet the growing demands for it, especially for the framing of our ships of war. For this particular purpose, where it is generally used in bulk to nearly the full growth of the tree, preference may even be given to it over English Oak.

Of the different varieties of Italian Oak, the Tuscan, Neapolitan, and Sicilian are the hardest and most horny in texture, and, when thoroughly seasoned, by far the most difficult to work; while the Modena, Roman, and Sardinian are what the workmen call milder in character—that is to say, they are easier to work, and a little less hard than the former.

The Modena and Sardinian also yield an easier curved form of timber than the other kinds, and do not split to the same extent in seasoning; they are all,

however, very much of the same strong character, and it is a fact worth mentioning, as showing the unusual hardness of this kind of timber, when well seasoned, that I have known many sawyers, when only entered temporarily in the dockyards for some pressing work to be done, leave rather than be employed in cutting this timber.*

In the employment of this wood very few defects are found, and no better evidence is necessary to show that great care is taken of it during its growth. It has both the star and the cup shake, but neither of these defects are very common in the Oaks grown upon the mainland or in the island of Sardinia. The Sicilian Oaks have, however, rather extensive cup-shake defects.

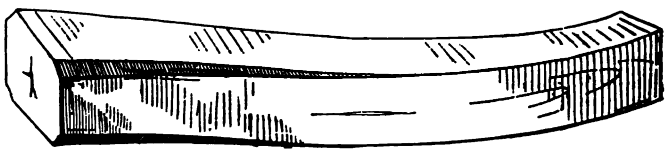
It was stipulated in the conditions of the navy contracts that about three-fourths of all the Italian Oak timber should be of compass form—that is to say, to qualify it as such, it must have at least five inches of curve in twelve feet, taken in any part of the length of the log; and this proportion was almost invariably obtained, while many of the logs which did not pass for compass had generally more or less curve, and a straight log was quite the exception.

* The following note is extracted from the first edition (p. 85). Very large supplies of this description of timber were sent to H.M. dockyards during the years 1860 to 1863, the greater part of it having been contracted for just prior to the introduction of iron ships for war purposes. But the wooden fleet having been almost superseded by the time it was delivered, a considerable quantity of it is still upon hand (1875); yet even now, although much of it has been from ten to twelve years in store, it is for the most part in a good state of preservation. The French Government for a long time drew upon the Italian states for considerable quantities of this Oak for the use of their dockyards, and were often competing with our own for the possession of it; thus, until quite recently, Italian Oak was an important and valuable article to the two chief naval powers of the world.

The specification under which Italian Oak (Fig. 21, *a* and *b*) was received stood as follows, viz.:—

	Price per Load of 50 feet. £ s. d.
Pieces containing each 30 feet and upwards cube	
,, ,, ,, 20 feet and under 30 feet	
,, ,, ,, 14 feet and under 20 feet	
Pieces under 14 feet contents, sided 9 to 11½ inches, inclusive, and not less than 10 feet long	
Pieces under 14 feet contents, sided 7 to 8½ inches, inclusive, and not less than 8 feet long...	

FIG. 21*a*.



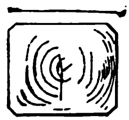


FIG. 21*b*.

All the timber to be winter-felled. Pieces sided 7 to 8½ inches, inclusive, to have at least 8 inches curvature in 8 feet in some part of its length.

The straight timber, excepting that sided 9 to 11½ inches, inclusive, to be 20 feet and upwards in length . . . . and both compass and straight timber to measure in the middle between the wanes, or to have pane at that place, not less than the siding of the piece with one-eighth part added thereto, and the pane at the top end not to be less than three-fourths the siding of the piece.

All the timber to be fairly tapered from end to end, and not to have more wane at any part than 4 inches on the two wanes taken together; or, if there is no wane on one edge or angle, and it is only on the other edge or angle, that wane is not to exceed 4 inches.

The compass timber to be sided from 7 to 20 inches, inclusive, and no part thereof, except of from 7 to 11½ inches sided, to be less than 13 feet in length.

The transverse strength of Italian Oak is shown in Tables XXVII., XXIX., and XXX., and the vertical strength in Tables XXVIII. and XXXI.; but there are

fewer experiments on these than on most other woods, owing to the difficulty that was found in obtaining a length of seven feet with a clean straight grain for testing.

TABLE XXVII.—ITALIAN OR TUSCAN OAK.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	4·50	·15	7·25	766	1011
2	3·75	·15	9·25	659	1094
3	2·15	·00	7·35	625	985
4	4·65	·20	6·85	906	1018
5	4·50	·15	8·55	777	1025
6	3·00	·15	6·75	813	1110
Total . .	22·55	·80	46·00	4,546	6243
Average .	3·76	·133	7·66	757·66	1040·5

REMARKS.—All the specimens broke with fibrous fractures, 10 to 16 inches in length.

TABLE XXVIII.—ITALIAN OR TUSCAN OAK.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.
Tons. 10·00	Tons. 9·75	Tons. 9·5	Tons. 9·75	Tons. 10·00	Tons. 9·5	Tons. 58·5	Tons. 9·75
*2·50	2·437	2·375	2·437	2·50	2·375	9·75	2·437

* On 1 square inch.

TABLE XXIX.—ITALIAN OR MODENA OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 350 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·25	·05	5·65	848	1130
2	2·30	·05	6·70	787	1103
3	2·25	·05	6·15	881	1121
4	2·70	·15	7·00	823	1060
5	2·25	·10	6·25	859	1092
6	2·25	·05	6·00	859	1150
Total . .	14·00	·45	37·75	5,057	6656
Average .	2·33	·075	6·291	842·83	1109·3

REMARKS.—Nos. 1, 5, and 6 broke with fractures slightly scarph-shaped; 2, 3, and 4 had long fibrous fractures.

TABLE XXX.—SARDINIAN OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 350 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·65	·05	5·75	765	1002
2	2·75	·10	5·65	659	1030
3	3·15	·15	4·85	630	1025
4	2·25	·15	8·00	906	943
5	2·50	·15	8·25	776	973
6	2·35	·15	6·50	812	970
Total . .	15·65	·75	39·00	4,548	5943
Average .	2·608	·125	6·5	758	990·5

REMARKS.—Nos. 1, 2, and 3 broke rather short to 1-5th the depth, and had about 12 inches length of fracture under it; 4, 5, and 6 had 13 inches length of fibrous fracture.

TABLE XXXI.—SARDINIAN OAK.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.
Tons. 10·00	Tons. 10·125	Tons. 10·625	Tons. 10·750	Tons. 10·000	Tons. 11·000	Tons. 62·500	Tons. 10·416
*2·5	2·531	2·656	2·687	2·500	2·750	10·416	2·604

* On 1 square inch.

TABLE XXIX.—ITALIAN OR MODENA OAK.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	2·25	·05	5·65	848	1130
2	2·30	·05	6·70	787	1103
3	2·25	·05	6·15	881	1121
4	2·70	·15	7·00	823	1060
5	2·25	·10	6·25	859	1092
6	2·25	·05	6·00	859	1150
Total . .	14·00	·45	37·75	5,057	6656
Average .	2·33	·075	6·291	842·83	1109·3

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6	2·35	·15	6·50	812	970
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Average .	2·608	·125	6·5	758	990·5

REMARKS.—Nos. 1, 2, and 3 broke rather short to 1-5th the depth, and had about 12 inches length of fracture under it; 4, 5, and 6 had 13 inches length of fibrous fracture.

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No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.
Tons. 10·00	Tons. 10·125	Tons. 10·625	Tons. 10·750	Tons. 10·000	Tons. 11·000	Tons. 62·500	Tons. 10·416
*2·5	2·531	2·656	2·687	2·500	2·750	10·416	2·604

* On 1 square inch.

CHAPTER XV.

EUROPEAN TIMBERS—(*Continued*).

DANTZIC OAK (*Quercus*).

THIS Oak derives its name from the port of shipment, but is chiefly the produce of the Polish forests, whence the bulk of it is brought down the river Vistula to Dantzic; small quantities are also sent into the ports of Memel and Stettin by other sources.

There is a considerable quantity of Oak timber exported from these three places in logs, varying from 18 to 30 feet in length, and from 10 to 16 inches square, and also planks 24 feet and upwards in length, averaging about 32 feet, the breadth being from 9 to 15 inches, and the thickness varying from 2 to 8 inches. Large quantities of staves, roughly cleft from the tree, are also exported in various sizes, suitable for the manufacture of every description of cask or barrel.

The Dantzic-Polish or Prussian Oak timber is obtained from a tree of straight growth. It is brown in colour, of moderate strength and hardness, rather porous, and has the medullary rays bright and sufficiently distinct to qualify it in some instances for wainscot

purposes. It is of fair durability, and is largely used in the construction of the mercantile ships of this country, but only sparingly for our ships of war, except for their decks, for which purpose it has been regarded as peculiarly fit, as it stands well the wear and tear of the gun carriages. For planking it is much esteemed, as the grain is straight, clean, and almost free from knots, but its price is prohibitive. Further, it is so pliable and elastic, when boiled or heated by steam, that it may be bent into the most difficult of curved forms without showing any sign of fracture.

This description of timber is carefully classified by the merchants, and divided into crown and crown brack qualities, the former being selected from trees of the fairest growth, clean in the grain, and generally free from every kind of coarseness and defect, while the crown brack includes the short and irregularly grown trees, and all those of a rough, coarse, and knotty character.

With the Oak planks they are more particular than with the timber, and endeavour to secure uniformity in their arrangement by employing a sworn bracker to make the classification. Thus the planks of each thickness are sorted into first and second qualities, or rather into crown and crown brack qualities as understood in the trade, and are respectively distinguished by the mark W on the best, and WW on the second best, plainly rased upon the side of the plank. Those of the crown quality are selected from the finest and fairest grown trees only, the crown brack being made up of planks produced from trees of less regular growth, including the coarse and sometimes faulty pieces. The commercial values of the two bracks vary both in the

timber, and in the plank, in about the proportion of three to two.

In civil architecture, the Dantzic Oak may be used with advantage for a great variety of purposes, as it stands well, shrinks only moderately, and without splitting much in seasoning.

The Navy contracts for Dantzic Oak do not include square timber, but thick-stuff of 7 to 4½ inches, and plank of 4 to 2 inches only, which are received under the following specification :—

The Dantzic Oak thick-stuff and plank to meet at 32 feet, and none to be shorter than 24 feet; and to be from 10 to 13 inches broad, averaging 11 inches clear of sap. The whole to be fresh, clean, free from defective wanes, cut regular, square-edged, and straight; the breadth for measurement to be taken clear of sap at the middle of the length; 67 per cent. of each thickness to be of first or crown quality, and the remainder of second or crown brack quality.

Tables XXXII. and XXXIII. show that the Dantzic Oak, when tested transversely, or tensilely, is of moderate strength; and, according to Table XXXIV., when tested for the vertical or crushing strain, it proves to be strong, and compares favourably with the British Oak.

TABLE XXXII.—DANTZIC OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	4·30	·15	5·25	474	850
2	4·35	·25	5·25	466	812
3	5·55	·30	6·85	449	817
4	5·75	·25	7·00	456	768
5	5·20	·25	7·85	508	897
6	4·85	·25	6·55	488	872
Total . .	30·00	1·45	38·75	2,841	5016
Average .	5·00	·24	6·458	473·5	836

REMARKS.—All the specimens broke rather short.

TABLE XXXIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	812	13,444	3,361
8		817	14,276	3,569
9		850	17,920	4,480
10		872	21,840	5,460
Total . .	...	3351	67,480	16,870
Average .	...	838	16,870	4,217

TABLE XXXIV.

Vertical or Crushing Experiments.

Nos.	Dimensions.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Total tons.	Average tons.	Ditto on 1 square inch.
11—16	1" × 1" × 1"	3·575	3·875	3·625	3·750	3·9375	3·875	22·6375	3·7729	3·773
17—22	2" × 2" × 2"	13·500	13·250	13·375	13·750	13·8750	13·250	81·0000	13·5000	3·375
23	3" × 3" × 3"	28·500	...	...	...	...	...	...	28·5000	3·166
24	4" × 4" × 4"	49·000	...	...	...	...	...	...	49·0000	3·062
25—28	2" × 2" × 1" 2" 3" 4"	14·125	13·500	14·000	14·250	...	...	55·875	13·9690	3·492

TABLE XXXV.

Experiments on specimens of Dantzic Oak.

Nos. 29, 30, and 31, to ascertain the elongation of the fibres in a length of 3 feet, taken under various strains, the dimensions of the pieces being 2 by 2 by 48 inches.

3 Tons.	4 Tons.	5 Tons.	6 Tons.	7 Tons.	8 Tons.	9 Tons.	10 Tons.	11 Tons.	12 Tons.	13 Tons.	Elongation preceding rupture.	Breaking strain in tons.
Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	
1/32	1/16	3/32	2/16	5/32	3/16	7/32	4/16	4/16	...	...	4/16	11·25
1/32	1/16	2/32	2/16	5/32	3/16	7/32	4/16	4/16	4/16	4/16	4/16	13·25
1/32	1/16	2/16	3/16	4/16	...	...	...	...	...	...	4/16	7·50
Mean ·0312	·062	·0937	·146	·187	·218	·25	·25	·25	·25	·25	·25	10·666

CHAPTER XVI.

EUROPEAN TIMBERS—(*Continued*).

RIGA OAK (*Quercus*).

THIS Oak, like the preceding, takes its name from the port of shipment, and is the produce of a tree found some distance in the interior of Russia, whence it is brought by the river Düna to Riga. Its dimensions are only moderate, and, as it is far from being abundant, very little ever reaches this country, except in the form of wainscot logs.

It is characteristic of this Oak timber, that the medullary rays are very numerous and more distinctly marked than is the case with the Dantzic Oak; but, otherwise, the wood is in colour, texture, fineness of grain, and general appearance, very much the same, as is also its strength and specific gravity. There is no reason, therefore, to doubt its fitness for employment in civil architecture, or for general purposes, but it is chiefly shipped to this country to meet the demand for ornamental work, and for the manufacture of furniture.

To prepare it for the London market, the butt lengths of the tree are slightly hewn upon two opposite

sides, and then sawn down the middle; the logs have thus a nearly semicircular form (Fig. 22), the average contents of each being only about 16 feet cube. This timber derives its chief value from the figured appearance it presents when cut, or converted in the direction of its medullary rays into boards or veneers for cabinet purposes.

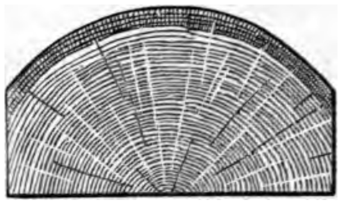


FIG. 22.

Riga wainscot timber passes through the process of bracking prior to its being shipped, and dealers have the option of making their selection from either the Riga, English, or Dutch crown qualities—or the brack quality—at prices varying with the market rates. It is sold by the log of 18 feet cube, a peculiarity in the mode of selling which is exclusively confined to this description of timber.

CHAPTER XVII.

EUROPEAN TIMBERS—(*Continued*).

THE OAK (*Quercus*).

THE foregoing are the principal European Oaks at present employed in this country; others have occasionally been brought in, and there are many new and extensive sources of supply open to us whenever it may be necessary to draw upon them.

A few years since I surveyed several fine forests of Oak in Belgium, consisting chiefly of trees of straight growth and superior dimensions. The wood of these was less hard and horny, and of slightly inferior quality to the English and French Oaks, but otherwise it was quite suitable for architectural and other works. There is, therefore, reason to believe that much good timber might be drawn thence. Very good samples of Oak timber have been imported from Piedmont. The quality closely resembles that of the Oak found in the west of France.

Oak timber has also been imported from Spain in considerable quantities, for ship-building and other purposes. The logs were generally small, or, at the best, of only medium dimensions, curved or crooked at the butt-end, and tapering rather quickly towards the

top. The wood of the Spanish Oak is of a dark brown colour, plain and even in its grain, porous, softer than most other Oaks, and liable to excessive shrinkage in seasoning.

TABLE XXXVI.—DUTCH OR RHENISH OAK.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	3·50	·25	5·25	658	1035
2	4·00	·25	6·65	650	1100
3	3·50	·30	6·75	625	1020
4	3·50	·35	7·15	630	940
5	3·25	·25	8·00	710	1082
6	3·50	·25	6·50	680	1080
Total . .	21·25	1·65	40·30	3,953	6257
Average .	3·54	·275	6·716	658·8	1043

REMARKS.—Each piece broke with a moderate length of fracture.

The star-shake defect is common to it, and, taken altogether, it is of very inferior quality. The Spanish Oak did not meet with approval in either the royal or private ship-building yards, and consequently the shipments of it to this country have declined for some time past. It is remarkable that this Oak is of very slow growth (*vide* Table I., p. 44); and perhaps this in some measure accounts for its inferior quality, the explanation being that the trees of this species which form and mature their wood most rapidly are generally the best of their kind, because when the summer and autumn zones are broad the whole annual ring is denser and more solid, since it contains more fibres, etc., and fewer and smaller vessels—*i.e.*, it is less spongy in texture.

There are, besides the Oaks already mentioned, several others which have not yet been brought sufficiently into use for their capabilities to be fairly tested; and among these are the Oaks of Turkey. In the year 1859, when the supply of British Oak was thought to be insufficient, and the Italian forests were showing signs of clearance and gradual exhaustion, the Admiralty, deeming it prudent to seek for other sources of supply for the service of their dockyards, directed surveys of the Oak forests in the district of Broussa, in Asia Minor. Having been intrusted with this duty, I found a vast number of very fine Oak trees, both of straight and compass form. Without doubt much good timber exists there; it is not, however, nearly equal in quality to the British Oak, although it would be likely to prove a good substitute for it if need required.

TABLE XXXVII.—SPANISH OAK.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	4·25	·25	6·00	626	1032
2	3·50	·20	6·15	616	1076
3	3·65	·25	5·65	544	1030
4	4·75	·35	7·75	509	1066
5	3·85	·25	8·00	578	1020
6	4·15	·20	6·15	497	1028
Total . .	24·15	1·50	39·70	3,370	6252
Average .	4·025	·25	6·616	561·66	1042

REMARKS.—Each piece broke short; in no instance was there more than 3 to 4 inches of fracture.

Two kinds of Oak were met with in the forests to the south-east of Broussa, that upon the upper ranges of the mountains being similar in foliage and fruit to the English *Quercus Robur*; the other species, which is found chiefly upon the slopes and in the valleys, is the *Quercus Cerris*, or Mossy-cupped Oak.

It was from these forests that most of the supplies were drawn for the service of the imperial dockyards at Constantinople and Gimlek; the Turks very carefully selecting the cleanest-grained trees for employment, and apparently neglecting the hard, gnarly-looking trees that would be difficult to work. They seem generally to be quite content with a mild and free specimen, which would require little labour to dress it to the necessary form; and therefore no correct opinion of the quality of the timber in the forests of the Broussa district can be formed from that seen in use in the naval establishment on the Golden Horn.

In the following year (1860) I made an inspection of several of the forests in Herzegovina, Bosnia, and Croatia, in European Turkey, and also some of the Oak forests in Styria and Hungary, meeting with almost inexhaustible quantities of Oak spread over the slopes of the Kogaratz mountains, and in the district between the rivers Verbas and Okrina.

The Oaks seen over this wide range were chiefly of the species *Quercus sessiliflora*, but mixed occasionally with *Quercus Cerris*; they were all of straight growth, with long clean stems, and generally of good quality, but varying considerably in this respect according as the situation and soil were favourable or otherwise to the development of their character. There is, however, good reason to believe that by selecting from the best description of Oak trees in the districts I have named,

very large and valuable supplies might be obtained; but at the time spoken of no attempt had been made to fell them for the many purposes for which their quality and size would render them available. The principal, and almost the only use hitherto made of any of these noble trees, is to cut them down and cleave them into staves for casks.

Bordering close upon the east side of Bosnia, but in the State of Servia, there are immense forests of Oak. These, however, I was unable to penetrate, owing to the lateness of the season and unfavourable state of the weather.

Hungary also possesses large forests of Oak, stretching from Resnek and Kaniza to the Danube. These again might undoubtedly be worked with great advantage, the trees being mostly of good quality, and remarkable for their straight growth and noble dimensions. In Styria could be found only a scanty stock of Oak, the forests having been exhausted some few years prior to the date of my visit. New supplies are, however, springing up, and ere long a very valuable property in this description of timber will be found there.

CHAPTER XVIII.

EUROPEAN TIMBERS—(*Continued*).

WALNUT (*Juglans regia*).

THE Walnut (*Juglans regia*) is found widely spread over Southern Europe, and in many parts of Asia. It is not a native of this country, though it has been planted for more than 300 years.

That which is brought from Italy is a light-brown wood, close and fine in the grain, with occasionally dark veins, and some waviness of figure; it is hard, heavy, solid, and with scarcely any disposition to split in seasoning. Planks 4 to 9 inches thick, square edged, 10 to 16 inches broad, and 5 to 12 feet in length, are imported and sold, sometimes by weight, at other times by the superficial foot of 1 inch thick.

The Black Sea Walnut wood is imported in logs of 6 to 9 feet in length by 10 to 18 inches square, imperfectly hewn, a considerable quantity of wane being usually left upon the angles. The wood is similar in colour and texture, but slightly inferior in quality, to the Italian Walnut wood; it is dealt with in the market under the same conditions.

Burrs or excrescences, frequently measuring 2 to 3 feet across by 12 to 15 inches in the thicker part, and

weighing 5 to 6 cwt. each, are common to the Walnut trees of Italy and the Black Sea; they are often prettily mottled or figured, and make rich and splendid veneers for the cabinet-maker; those of the best quality are consequently much prized, and have been known to realise £50 to £60 per ton weight.

ASH (*Fraxinus excelsior*).

Among British timber trees this occupies a very prominent place, on account of its great beauty and highly ornamental character. It attains commonly a height of 30 to 50 feet, with a circumference of from 5 to 6 feet, and grows in almost any description of soil, but prefers a rich deep loam and moisture to bring it to the greatest perfection.

We find it frequently raised in coppices. In the pottery districts, owing to its value as crate wood, it is cut every five or six years, while in other places it is cut down only at intervals of seven or eight years. From the early falls poles for lances are obtained, besides much that is useful to the cooper, the turner, and manufacturer of small wares. The later falls yield timber of more useful dimensions, and this is exceedingly valuable to the coachmaker and the wheelwright.

The wood is greyish-white in colour, of moderate weight and hardness, very even and close in the grain, tough, elastic, easily split or worked, and very pliable. To the carpenter, however, it is only found to be available for very minor purposes, as, owing to its great flexibility, it can never be safely used in architectural works, though it warps but little. For hoops, and all kinds of agricultural implements, however, it is invaluable, since when steamed or heated it can easily be

bent into any form of curve required, without injury to the fibre.

It is peculiar to the Ash that it has a very broad sap-wood—comprising about forty annual rings—that is to say, there is for a long time in the growth of the timber no perceptible difference between the first-formed and the later or outer layers; since this sap-wood can be utilised directly after seasoning, there is thus an advantage in the employment of this description of wood over that of most others for any of the purposes for which it is adapted, as it can be utilised to the full diameter of the tree.

Ash is extremely durable if felled in the winter months and properly seasoned before use; but where these precautions are neglected few woods are more perishable. Very great advantage will be found in reducing the Ash logs soon after they are felled into plank or board for seasoning, since, if left for only a short time in the round state, deep shakes open from the surface, which involve a very heavy loss when brought on later for conversion.

Ash wood, when beginning to decay, changes at the centre to a blackish colour, as also it will do if the trees are pollarded or topped off during growth, hence the "best quality" should be uniformly greyish-white throughout. Such wood is invaluable for carriage work, oars, and all purposes where elasticity and strength are required.

There are several varieties of the Ash which attain timber size, and those which are raised for ornamental purposes in this country are very numerous. This tree is remarkable for its lateness in putting out its leaves in the spring, and for throwing them off very early in the autumn.

TABLE XXXVIII.—ASH (ENGLISH).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches	lbs.	
1	1·75	·05	8·50	879	750
2	1·50	·05	8·75	845	722
Total . .	3·25	·10	17·25	1,724	1472
Average .	1·625	·05	8·625	826	736

TABLE XXXIX.
Tensile Experiments.

Number of the specimen.	Dimensions of the piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
3	2 × 2 × 30	750	15,120	3,780

TABLE XL.
Vertical or Crushing Strain on cubes of 2 inches.

No. 4.	No. 5.	No. 6.	No. 7.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
13·	12·	12·25	12·5	49·75	12·4375	3·1094

BEECH (*Fagus sylvatica*)

is found in abundance in the central and southern districts of this country, and is also extensively spread over the middle and south of Europe. It is of erect and

straight growth, attains the height of 60 to 70 feet, with a circumference of from 10 to 12 feet, and being of very hardy habits, is often planted in the most exposed positions, to lend beauty and picturesqueness to the surrounding scenery.

The wood is reddish-white or light brown in colour, hard, heavy, close and even in texture, with a fine silky grain. It cleaves easily, works up well, and is remarkable for its minute vessels, and for the distinctness with which the medullary rays can be traced.

Beech is employed for chair-making, and it is estimated that at least 12,000 to 15,000 loads are annually required from the English forests for this purpose. Engineers use it for piles and works under water, and it is in great request by turners, tool-makers, and others, who use it extensively in the domestic arts. It makes excellent wedges.

Formerly it was employed in ship-building, and found to answer admirably for the keel and garboard planking; it was also used for the ladders between decks, shot cants, and for many minor services. Owing to the important property the Beech has of not absorbing water readily, it is much used on the Continent for making shoes, and soles for shoes, these being considered far superior to any made of other descriptions of wood. It is also a most valuable article of fuel.

Beech is durable if kept wholly submerged in water or mud; it is also durable if kept quite dry, but if left exposed to the alternations of the weather, it soon becomes dotted over with yellowish spots, and rapidly decays.

No suitable pieces were available for experimental purposes to try its transverse strength, but the tensile was ascertained by experimenting on three pieces, the *average giving* 4,853 lbs. per square inch; tried vertically

upon four pieces the average was 3·812 tons per square inch. The specific gravity of the seasoned wood varies from 700 to 720, and averages about 705.

BIRCH (*Betula alba*, or Common Birch)

is found in nearly every country in Europe. In Bosnia, Turkey, however, the author only met with it on the skirts of forests upon the mountains at a considerable elevation.

The European Birch grows naturally a little crooked in the stem, with light, oblique branches, slightly drooping at the extremities, and attains, sometimes, the height of 50 feet, with a diameter of 18 inches, but generally it is of very moderate dimensions. It flourishes on a poor soil in any exposed situation, and is very hardy.

The wood is of a light brown colour, moderately hard, plain and even in the grain, and is easily worked; but it is neither strong nor durable, and is therefore unfit for building purposes. Its chief uses are for cabinet work, chair-making, turnery, and light wares generally. The bark is smooth, thin, white in colour, and is used in tanning. Birch timber is imported in a round state and with the bark on from the North of Europe to our northern ports, and passes into the manufacturing districts for use in a variety of ways. Very little, however, comes to the London market.

CHESTNUT (*Castanea vesca*).

The sweet Chestnut attains to large dimensions, and is found thinly scattered over most of our southern English counties, though it is not really a native tree. It is abundant in the southern parts of Europe, and

extends eastward to the Caucasus. It is also met with in the mountainous parts of Virginia, Georgia, and Carolina, in North America.

The wood is brown in colour, of moderate hardness and weight, has a clean fine grain, and is rather porous. The medullary rays can scarcely be distinctly traced in it by the unaided eye, and it has a very narrow alburnum or sap-wood. The characteristic points, which serve to distinguish it from the British Oak, for which it has sometimes been mistaken, are the want of broad medullary rays, and certain features in the numerous fine ones. There is also this further difference between them, the Chestnut is of slower growth than the British Oak.

The Chestnut timber stood in high favour at one time, and it is even supposed that preference was given to it over Oak for employment in some of our oldest and best specimens of civil architecture, but upon careful examination of the woods during reparations it has generally proved to be Oak of native growth that had been used, and not Chestnut.

The Chestnut is scarcely ever used now except for very common or ordinary works, such as posts, rails, palings, hop-poles, &c.; but as it is durable when kept wholly submerged, it may be used for piles, sluices, &c., with advantage.

It is on record that specimens of the sweet Chestnut have attained to a very great size and remarkable longevity; one standing lately in Sicily is said to have measured 160 feet in circumference; the centre part, however, was quite gone, and the cavity thus formed was considered to be sufficiently large to give shelter to a troop of at least eighty men. Another, but much smaller, in the department of the Cher, France, measured over 30 feet in circumference; this has been known for five or

six centuries as the great Chestnut tree, and must be of very great age.

ENGLISH ELM (*Ulmus campestris*)

is found growing in the hedgerows of most of the counties, and forming the avenues in many of the parks of England. It also occupies a wide range over Europe, preferring generally low lying, level ground, with a moderate degree of moisture. It thrives on many varieties of soil, provided the situation be open, but attains the greatest perfection when grown in a deep, open loam, reaching, under favourable circumstances, the height of 60 to 70 feet, with a circumference of from 7 to 8 feet.

The wood is brown in colour, heavy, hard, tough, porous, and much twisted in grain, which makes it difficult to work when thoroughly seasoned, and also next to impossible to split it. The medullary rays in this species of wood are so fine as to be hardly distinguishable, and this in some measure accounts for its strong cohesive properties.

The economical uses of the Elm are very great, since we find it extensively employed in engineering works for piles, pipes, pumps, blocks, &c.; it is also used for keels and planks under water in ships. Carpenters, wheelwrights, turners, and cabinet-makers also use it for so many purposes that it would be very difficult to enumerate them.

Elm timber, if used either where it is constantly under water, or in any situation where it is kept perfectly dry, excels almost every other kind of wood in durability. But under any other circumstances it decays rather rapidly; therefore, the surveyor, in selecting this wood,

should, if he requires it for any purpose where durability is an object, decline to take any but fresh-cut logs, since, if they have been left for more than about ten to twelve months exposed to the weather, they will be liable to prove faulty, and very possibly may have changed from the natural brown to a yellowish colour, which is a sure sign of a deterioration in the quality. The bark of Elm usually falls off in about ten to sixteen or eighteen months after the tree is cut down, the surface after this gets blanched by exposure, and there are few logs that have been felled so long that are quite free from incipient decay.

There is almost no heart, cup, or star-shake in the common English Elm, but the defects are often nevertheless of a very serious character, and are chiefly occasioned by the rough treatment it is subjected to in the way of pruning—the knots or root end of the branches being left exposed, decay and wet-rot frequently soon follow, then hollow places are formed in the centre, and the tree is ruined. Birds frequently build in these cavities, and it occasionally happens in working this wood that perfect nests, with fresh-looking eggs, are found deeply buried in the log.*

The sap-wood of Elm timber is generally from 1½ to 3 inches thick, but it forms an exception to the rule which forbids the employment of sap-wood in architecture, as all parts of it have been proved to be equally durable. The waste, therefore, to be incurred in the conversion of the log is very small, provided always that the planks and boards are only cut as they are required.

* Acorns have been found in such positions, the stores of a squirrel having been buried in a mass of the invading mycelium of a tree-destroying fungus. (See "Timber and some of its Diseases," by Marshall Ward, p. 169.)

This precaution is considered necessary, owing to the great liability of the planks to warp or twist, which would soon render them unfit for use.

As Elm timber is best and most durable when worked up soon after the tree is felled, it is not necessary to keep in store more than is required from year to year. If, however, it should be thought desirable to accumulate stock with the view to provide against emergencies, it will be most effectually preserved for future use by keeping it constantly under water, or burying it in mud.

Table XLI., showing the transverse strength of this wood, is not so full or satisfactory as could be desired, owing to the difficulty experienced in finding pieces sufficiently straight in the grain for experimental purposes. The Tables XLII. and XLIII., showing the tensile and vertical strength, are, however, more reliable.

TABLE XLI.—ELM (ENGLISH).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inches.	Inches.	lbs.	
1	...	...	3·50	...	578
2	5·25	1·25	7·50	510	571
3	...	...	6·25	...	558
4	...	...	4·00	...	553
5	4·75	1·30	5·50	350	545
6	4·70	1·35	5·00	320	542
Total . .	14·70	3·90	31·75	1,180	3347
Average .	4·90	1·30	5·291	393	558

TABLE XLII.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	690	21,060	5,040
8		625	26,880	6,720
9		611	18,480	4,620
Total . .	...	1926	66,420	16,380
Average .	...	642	22,140	5,460

TABLE XLIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	No. 15.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·125	10·00	10·75	10·50	10·25	10·375	62·00	10·333	2·583

Contracts are annually made for the supply of English Elm timber for the royal navy, according to the following specification and conditions, the quantities of the several classes, and the quantity required for each of the dockyards, of course varying from year to year, *to suit* the works in hand.

SPECIFICATION.

ENGLISH ELM TIMBER.

Contents of each log.	Loads.	Price per load.
Feet. Feet.		£ s. d.
190 to 300		
189 " 160		
159 " 130		
129 " 100		
99 " 70		
99 " 60 (Wych) . .		
Under 60 " . .		
75 to 250 (for Blocks) .		
Total		
Of which are to be fit for keel-pieces . .		

A premium price was formerly paid by the Admiralty for timber suitable for keel-pieces; logs qualified for this purpose were not to exceed 250 feet cube.

The conditions of the contract were as follows:—

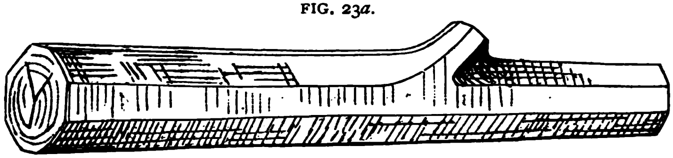
1. That all the timber should be felled in the winter; that is, within the 1st November and the end of February.

2. The timber would not be required to be delivered of an octagonal form, but must be so hewn or squared as that at each of the measuring places no surface or square shall be less than one-fourth of the diameter of the piece where the measurement is to be taken (Fig. 23*b*); and in measuring at the yards, the contents of the butt-lengths will not be taken separately, but the lengths for measurement will be regulated by the several stops or joggles.

3. The common Elm timber to be fairly grown and free from sudden bends (Fig. 23*a*); to be 24 feet in length and upwards, meeting at 28 feet; and each piece of timber to be measured for contents by calliper measurement, as far as the spire (which is not to be cut off from any tree) will hold 15 inches in diameter; and no top will be received except the spire. No tops will be received at the yards detached from the log.

4. The Elm timber for keel-pieces to be straight, fairly grown, and to square 17 inches and upwards. The shortest length is to be 28 feet.

FIG. 23*a*.



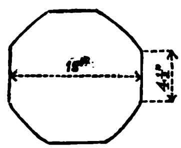


FIG. 23*b*.

5. The Elm timber for blocks to be clean butt-lengths, free from knots; to be 16 feet in length and upwards, meeting at 20 feet. The calliper measure of the mid-length to be not less than 26 or more than 36 inches.

6. The Wych Elm timber to be 16 feet in length and upwards, meeting at 20 feet; each piece of timber to be measured for contents by calliper measurement as far as the spire (which is not to be cut off from any tree) will hold 8 inches in diameter; no top will be received

except the spire. No tops will be received at the yards detached from the log; all the timber to be of fair growth, free from sudden bends and knots, and suitable for conversion into plank and board.

7. All the timber to have the bark on the wanes, to be good, sound, merchantable, well conditioned, such as shall be approved of by the officers of the respective yards, and in every respect fit for the service of Her Majesty's navy.

WYCH ELM (*Ulmus montana*)

is most abundant in the North of England and in Scotland, and is only sparingly scattered over the southern counties.

Ordinarily this description of Elm is of very moderate dimensions, although instances are by no means rare of its attaining a great size. In Evelyn's "Sylva," we are informed that a Wych Elm, which grew in the park of Sir Walter Bagot, in Staffordshire, measured 17 feet in diameter at the base, and was estimated to contain the large quantity of 97 tons of timber.

The Wych is readily distinguished from the common Elm by its smoother and thinner bark, by the absence of heavy branches low down on the stem, and by the larger size of the leaves.

The wood is of a light-brownish colour, rather more porous than the common Elm, tough, and moderately hard when seasoned. Being generally clean and straight in the grain, and very flexible when steamed, it is in great request for boat-building; in other respects its uses are as varied and numerous as those of the common Elm.

The so-called Dutch Elm closely resembles the

Wych Elm, and is found growing in this country under the same conditions of soil, aspect, &c.

The wood is somewhat darker in colour than the Wych, is tough, hard, and of the same porous and flexible character, but being more frequently subject to star-shake, it is considered to be an inferior variety, and is consequently less sought after. It is not generally so suitable for boat-board as the Wych Elm, but for any ordinary purpose it might be used as a substitute for either of the other kinds. In commerce it is known as the Dutch or Sand Elm.

The English Elm trees, of which several varieties are sometimes distinguished, are remarkable as being among the first in leaf in the spring, and the latest in shedding them in autumn.

HORNBEAM (*Carpinus Betulus*)

is an indigenous British tree, which grows even upon a comparatively poor soil, and attains the height of 40 to 50 feet with a circumference of from 30 to 45 inches.

The wood is yellowish-white in colour, close in the grain, hard, tough, strong, and of moderate weight; its pores are minute, the medullary rays are plainly marked, and there is no distinguishable sap or alburnum; it may, therefore, be worked up to great advantage. Hence we find it employed for a variety of purposes; it is useful in husbandry, and agricultural implements made of the sound and healthy wood wear well, as it stands exposure without being much affected by it. It is also used by engineers for cogs in machinery, a purpose for which it is well suited.

The Hornbeam tree, if pollarded, becomes blackish in colour at the centre, owing to the admission of ex-

ternal moisture and parasites. This renders it unfit for many purposes where a clean, bright surface is required, and generally it proves detrimental to the quality and durability of the timber.

This wood when subjected to vertical pressure cannot be completely destroyed, its fibres, instead of breaking off short, double up like threads, a conclusive proof of its flexibility and fitness for service in machinery.

Suitable specimens could not be secured of the standard dimensions to test the transverse strength of this wood, and consequently only the tensile and crushing or vertical strains appear in the tables.

TABLE XLIV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch
	Inches.		lbs.	lbs.
1	2 x 2 x 30	808	28,560	7,140
2	2 x 2 x 30	815	27,440	6,860
3	2 x 2 x 30	815	23,520	5,880
4	2 x 2 x 30	836	22,960	5,740
Total . .	...	3274	102,480	25,260
Average .	...	819	25,620	6,405

TABLE XLV.

Vertical or Crushing Strain on cubes of 2 inches.

No. 5.	No. 6.	No. 7.	No. 8.	Total.	Average.	Ditto on 1 square inch
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
14·25	15·	15·125	15·	59·375	14·844	3·711

BOX (*Buxus sempervirens*)

is found nearly all over the South of Europe, from Spain to the Sea of Marmora; but in this country only sparingly on warm, chalky hill-sides, as at Box Hill, near Dorking. The timbers termed "Boxwood" in the colonies, etc., come from very different trees.*

The Box tree seldom attains timber dimensions, and is not a building wood; it is, however, invaluable to the mathematical instrument maker, the turner, and the wood engraver, on account of the closeness of its grain and evenness of texture; and in the manufacturing districts it is in great request for bosses and boxes in connection with machinery.

Boxwood of excellent quality is imported from Abasia, in Circassia, and also from Turkey. It is brought in round logs or billets, 3 to 8 feet in length, by 3 to 12 inches in diameter, with the bark on, which is thin, smooth, and of a grey colour. It has no distinguishable sap-wood, and the annual ring and medullary rays are also invisible.

The wood is yellow in colour, hard, heavy, free from heart-shake, and about the most solid at the pith that can be met with. It works up smoothly and with a silky lustre.

Boxwood is liable to split somewhat spirally from the outside of the log, but stands well after being worked, when thoroughly seasoned; and as it is seldom required for use except in small dimensions, no great loss is ever sustained in its conversion.

Boxwood is sold by weight, and in the London and

* *E.g.*, in Australia several species of *Eucalyptus*, etc., in Jamaica *Tecoma pentaphylla*, in America *Cornus florida*, and so on.

Liverpool markets realises about 28s. per cwt. when sold in small quantities, as it usually is, according to quality and dimensions.

The specific gravity of Box varies from 950 to 980.

Boxwood is still regarded as the best for engraving, in spite of many attempts to replace it by various substitutes,* of which the Hawthorn (*Cratægus*) is perhaps the most satisfactory yet found, and certain American *Rhododendrons* and some species of *Diospyros.*

ALDER (*Alnus glutinosa*)

is a native of this country, and requires a moist porous soil to bring it to perfection. It is generally found near to streams, rivers, and swampy places, where it attains a height of about 50 feet, with a circumference of from 2 to 4 feet.

The wood is reddish-white in colour, soft, and light, with a smooth, fine grain. It works up well, makes good clogs and soles for shoes, and is used in a variety of ways, but is of no great value to the carpenter, except for the making of packing-cases. It has been used for piles, pipes, sluices, etc., and is durable when kept wholly submerged; it is not now, however, much in request for these purposes, as Elm timber is considered to be far preferable.

The wood of the stem is very plain, and only employed for minor services; but the roots and knots being often richly veined, are used by the turner and cabinet-maker for the manufacture of small wares. The bark is used by dyers and tanners, and charcoal made from the wood is employed in the manufacture of gunpowder.

* See Jackson, *Journal of the Society of Arts*, 1886.

WILLOWS (*Salix*).

There are about 160 species of Willows known, and many hybrids and varieties, making the determination of the forms very difficult. They yield soft, usually pale coloured, light and easily worked tough timber, of considerable value for certain purposes, owing to the wood denting instead of splitting when struck by heavy objects. The principal are the following:

Salix alba, the White Willow, used especially for poles. The Goat Willow or Sallow (*S. Caprea*), used for hoops, poles, crates, etc. The Crack Willow (*S. fragilis*), and the Osiers (*S. purpurea*, *S. viminalis*, etc.), used for making baskets.

Planks of the larger Willows are valued as linings for carts, barrows, etc., owing to their not splintering when struck by stones, bricks, etc., and blocks are prized for brakes, as they do not fire so readily as other wood by the friction on the wheels.

OTHER EUROPEAN TIMBERS.

Of the remaining European timbers the following are noteworthy:

Tilia Europœa, the Lime, or Linden, of which there are three varieties. The white soft wood is used in furniture making.

Maples, *Acer pseudo-platanus* (the Sycamore) has a yellowish-white wood, prized by cabinet-makers. *A. platanoides*, the Norway Maple, and *A. campestre*, the field Maple, are less valued.

Horse-chestnut (*Æsculus hippocastanum*), not much used.

Euonymus (Spindle tree), and *Rhamnus* (Buckthorn), are only employed for small turnery and charcoal making; similarly with the Holly (*Ilex*) and Barberry (*Berberis*) which are rarely used.

Laburnum (*Cytisus Laburnum*) has a beautiful greenish-brown heart, excellent for turnery and cabinet work.

The wood of the Plums (*Prunus domestica*) and Cherries (*P. Mahaleb*, *P. avium*, and *P. cerasus*), are only used in small turnery, and for pipes, etc. Pear-wood (*Pyrus communis*) is used for instruments and small cabinet and turnery work, and the wood of the Hawthorn (*Cratægus*), Rowan (*Pyrus Aucuparia*), and Service trees (*P. Aria*, *P. torminalis*, etc.) find similar small uses. The same applies to Elder (*Sambucus nigra*), Lilac (*Syringa vulgaris*), and Olive (*Olea Europæa*).

The Mulberry (*Morus alba* and *M. nigra*) is used for cabinet work.

The various Poplars, *Populus alba*, *P. tremula* (Aspen), and *P. nigra*, are little used.

CHAPTER XIX.

THE TIMBER TREES OF CANADA AND NORTH AMERICA.

PASSING now from Europe to America, it will be well to describe three or four of the most valuable kinds of Oak which have been dealt with commercially and employed in this country. There are many others spread over that vast continent; but, as they are little known here and not likely to be required, they will be only briefly noticed.

Of the large number of species of Oak—about 300—known to botanists, something like 40 or 50 are found in the United States: these are commonly divided into "White Oaks" and "Black Oaks," the former alone yielding really valuable timber, that of the Black Oaks being too soft and porous for constructive purposes.

AMERICAN WHITE OAK (*Quercus alba*).

This tree derives its name from the pale ash colour of its bark, and is said to flourish in almost every variety of soil, but best upon open ground at a moderate elevation, some of the finest specimens being found in Maryland. It is abundantly spread over a very large tract of country, and, according to Michaux, it extends from the 28° to

the 46° of North latitude, and towards the west to the State of Illinois.

In open situations the trunk of this tree is of only moderate length, but in the forests it frequently attains the height of from 40 to 60 feet clear of branches, with a circumference of from 7 to 8 feet, and very noble logs of timber are produced from it. Those which I have seen imported into this country have invariably been straight, and hewn to correspond in appearance with our English Oak "sided" timber; some of the logs were very large, but generally they varied from 25 to 40 feet in length, and from 12 to 28 inches in the siding or thickness.

Thick-stuff of from 10 to 4½ inches, and plank of 4 to 2 inches, of very superior lengths, fair growth, and free from knots, have usually formed part of the shipments. There is, however, scarcely any compass timber to be found beyond the little that can be obtained from the branches, or from the spurs of the roots, which are often very large.

The wood is of a pale, reddish-brown colour, straight-grained, moderately hard and compact, tough, strong, and of fair durability. Being remarkable for its elasticity, planks cut from it may, when steamed, be bent into almost any form or curve, no matter how difficult, without danger of breaking or splintering them. This characteristic renders it especially valuable for shipbuilding purposes.

This wood opens very sound; and as it shrinks but little, and almost without splitting, during the process of seasoning, there is nothing to prevent its extensive use in railway carriage-building, civil architecture, and generally in the domestic arts. I have known it to stand the test of many years' exposure in the open

without being more than very slightly deteriorated thereby. It will therefore be safe to say that it is by far the best foreign Oak timber, of straight growth and large dimensions, for constructive purposes that has ever been imported.

The American White Oak timber, introduced in 1861 by Mr. Donald McKay, of Boston, U.S.A., was used in the royal dockyards as a substitute for British Oak, chiefly for beams, keelsons, and other works requiring large scantlings. At the moment of its introduction, however, the great change took place by which iron was substituted for wood in ship-building; consequently the demand for it fell, and owing to the large stock of other woods at the time upon hand, it was difficult to employ it profitably. Ultimately it passed away in the repairs of ships and some minor services. Very little of this wood has ever been placed upon the London market for employment in the private trade.

In the experiments that were made, it was found White Oak compared very favourably with all the foreign Oaks, but proved to be slightly inferior in strength to the English Oak.

TABLE XLVI.—AMERICAN (OR PASTURE) WHITE OAK.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·65	·15	9·00	836	960
2	1·50	·00	8·50	826	988
3	1·75	·25	9·25	839	950
4	1·75	·10	10·15	882	1010
5	2·35	·35	9·35	744	935
6	2·50	·35	6·75	696	1054
Total . .	11·50	1·20	53·00	4,823	5897
Average .	1·916	·208	8·833	803·83	982·8

REMARKS.—Nos. 1, 2, 5, and 6 broke with a splintery fracture, 10 to 12 inches in length; 3 and 4, although splintered like the others, were not completely broken asunder.

TABLE XLVII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	988	28,004	7,001
8	2 × 2 × 30	960	31,076	7,769
9	2 × 2 × 30	935	26,600	6,650
10	2 × 2 × 30	1010	31,228	7,807
11	2 × 2 × 30	950	23,512	5,878
Total . .	...	4843	140,420	35,105
Average .	...	969	28,084	7,021

TABLE XLVIII.

Vertical or Crushing Experiments.

Nos.	Dimensions.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Total Tons.	Average Tons.	Ditto on 1 square inch.
12—17	1 × 1 × 1	3·125	3·00	3·125	3·000	3·250	3·500	19·000	3·166	3·166
18—23	2 × 2 × 2	12·000	12·75	12·500	12·125	12·750	12·500	74·625	12·437	3·109
24—27	2 × 2 × 1·2·3·4	9·750	9·06	9·750	10·250	...	...	...	...	...
28	3 × 3 × 3	22·500	...	...	...	...	...	...	22·50	2·50
29	4 × 4 × 4	33·000	...	...	...	...	...	...	33·00	2·06
30	9⅛ × 9⅛ × 15	247·000	...	...	...	...	...	...	247·00	2·97
31	9⅛ × 9⅛ × 24	247·000	...	...	...	...	...	...	247·00	2·97
32	12 × 12¼ × 30	338·000	...	...	...	...	...	...	338·00	2·30

AMERICAN LIVE OAK (*Quercus virens*).

This tree is of very moderate dimensions when compared with the White Oak, its usual height being only about 35 to 45 feet, with a diameter of 12 to 18 inches. It is an evergreen, and is found principally in the Southern States of North America, and near to the sea-coast, which it seems to prefer to the more inland and sheltered situations.

The wood is dark brown in colour, hard, tough, strong, heavy, and very difficult to work, on account of the grain being waved or twisted. Its pores are very minute and the medullary rays unusually bright and distinct.

The largest logs of live Oak that I have seen imported did not exceed about 18 feet in length by 12 inches square, and generally they were of much smaller dimensions. They are usually of a crooked or compass shape, and are, therefore, very suitable for the framing of ships of from 300 to 800 tons burthen, in which only small scantlings are required. It is used extensively for this purpose in the Southern States; it makes good mallets for carpenters, and would be useful for cogs in machinery, and many other services where great weight is not an objection.

Judging from the appearance of this timber, it is stronger than any other known Oak, but, as it was impossible to obtain a single straight specimen of the prescribed dimensions, viz., $2 \times 2 \times 84$ inches, the usual tests could not be applied, and there are consequently no tables to show what it would actually bear.

BALTIMORE OAK (*Quercus alba*)

is so called from the shipments being made chiefly from Baltimore, is a perfectly straight timber, and is brought to us in lengths varying from 25 to 40 feet, the squares, or sidings, being from 11 to 20 inches.

The wood is of a reddish-brown colour, somewhat darker than the White Oak, and less hard and horny in texture; it is moderately strong, and the quality fair. It might be used with advantage for many minor fitments in ships, and for general purposes in carpentry, as it is easy to work, and stands well after seasoning. It is not, however, recommended for use where great strength is required, as, when thoroughly dry, it is scarcely so strong as the best Fir or Pine.

The Baltimore Oak tree is of very slow growth (*vide* Table I., p. 44), and the timber would soon decay unless well protected by paint or varnish after seasoning.

TABLE XLIX.—AMERICAN (OR BALTIMORE) OAK.
Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·00	5·00	651	820
2	1·25	·15	7·50	837	695
3	1·35	·25	8·25	769	738
4	1·50	·15	7·15	729	736
5	1·85	·25	7·65	627	734
6	1·65	·35	7·25	723	758
Total . .	8·85	1·15	42·80	4,336	4481
Average .	1·475	·191	7·133	722·66	746·83

REMARKS.—Nos. 1, 3, and 6 broke quite short; 2, 4, and 5 with a scarph-like fracture, about 8 inches in length.

TABLE L.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	758	19,600	4,900
8		736	19,052	4,763
9		734	11,748	2,937
10		738	10,920	2,730
Total . .	...	2966	61,320	15,330
Average .	...	741·5	15,330	3,832

TABLE LI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 11.	No. 12.	No. 13.	No. 14.	No. 15.	No. 16.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·75	10·75	10·5	10·5	10·5	10·125	63·125	10·521	2·630

CANADIAN RED OAK (*Quercus rubra*).

This tree is of perfectly straight growth, and yields the timber of commerce in logs varying from 25 to 50 feet in length by 12 to 24 inches square.

The wood is brown in colour, has a fine straight clean grain, is somewhat porous, shrinks moderately without splitting, is easy to work, and stands well after seasoning. It is remarkable for its very slow growth.

Large quantities of this Canadian Oak timber are usually imported annually into London, and a far greater quantity into the Liverpool market, for the use of cabinet-makers and general dealers, who employ it for the manufacture of furniture, and in the domestic

arts; but, as a building wood, it can never be in favour, and is quite unfit for architectural or engineering works requiring strength or durability.

There are about half-a-dozen other Canadian Oaks of excellent quality, the Black Oak (*Q. tinctoria*), Red Oak (*Q. rubra*), Mossy Cup (*Q. olivæformis*), Swamp White Oak (*Q. prinus bicolor*), Pin Oak (*Q. palustris*), being the best.

The Canadian or Quebec Oak is the White Oak (*Q. alba*), but it is generally quoted in the market at about 20 per cent. higher than the Baltimore Oak: probably this is chiefly owing to its superior dimensions rather than to any difference in the quality.

America produces, besides the foregoing, the Rough or Post Oak (*Q. stellata*); the Rock Chestnut Oak (*Q. montana*); and the Scarlet Oak (*Q. coccinea*); all these are largely used in architectural works, and for agricultural implements, both in the United States and in Canada.

The chief Californian Oaks are the Long Acorned Oak (*Q. Hindsii*), the Chestnut Oak (*Q. densiflora*), and the Californian Evergreen Oak (*Q. agrifolia*), but their timber is of little value, and hardly known in commerce.

CANADIAN ASH (*Fraxinus sambucifolia*).

The timber of this tree is often confounded with the American White Ash, also found in Canada. It attains good dimensions, and yields the timber of commerce in logs varying from 20 to 40 feet in length, by from 10 to 16 inches square. Oar rafters are also produced from it, and until quite recently considerable quantities were brought to this country. These rafters are pieces roughly shaped to the form of oars, and reduced to a minimum of size, to lessen, as far as possible, the cost of freight.

The wood is reddish-brown in colour, and considerably darker than the English Ash. It is plain and straight in the grain, moderately hard and heavy, tough, elastic, and easy to work. It is very suitable for employment for oars to boats, and is consequently in great request for that service, while its economical uses are as wide and general as that of our native growth.

TABLE LII.—ASH (CANADIAN).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	2·5	·10	7·00	696	493
2	3·0	·15	7·75	580	467
Total . .	5·5	·25	14·75	1,276	960
Average .	2·75	·125	7·375	638	480

TABLE LIII.
Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
3	2 × 2 × 30	558	16,240	4,060
4	2 × 2 × 30	544	17,360	4,340
5	2 × 2 × 30	625	28,560	7,140
6	2 × 2 × 30	625	25,760	6,440
Total . .	...	2352	87,920	21,980
Average .	...	588	21,980	5,495

TABLE LIV.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
7·25	7·75	12·75	11·50	39·25	9·812	2·453

AMERICAN ASH, OR WHITE ASH (*Fraxinus Americana*), is found chiefly on the banks of the rivers of North America. It is of straight growth, and frequently attains a height of 70 feet, with a circumference of from 3 to 5 feet. It is imported into this country, only sparingly, in logs varying from 10 to 18 inches square, and 18 to 35 feet in length; but comes to us in considerable quantities in a partially manufactured state in the form of machine-made boat-oars, handspikes, &c.

The wood is light brown or whitish in colour, of very moderate hardness and weight, is tough, elastic, clean and straight in the grain, and quite easy to work; it stands well after seasoning, and hence we get from this tree the best material for oars for boats that can be produced. They are much and eagerly sought after by foreign Governments as well as our own, and also by the great private steamship companies and the mercantile marine of this country, consequently there is often a very keen competition for the possession of them.

The best quality wood has a clean, bright, uniform whitish colour, the second is slightly stained with red and yellow shades alternating, while the third, and most objectionable, quality is that in which the red and yellow colours predominate over the healthy shade. Any deviation, therefore, from the bright whitish colour may

be taken as indicating a deterioration which will affect its strength and durability.

The United States Ash is much slower in growth than the English, and is probably not so durable.

There are several other species of Ash in Canada and the United States, but none are of much importance as timber.

CANADA ROCK ELM (*Ulmus Americana*)

is found growing abundantly in the low woods of North America, from New England to the Carolinas. It attains moderate dimensions, with a clean straight stem, and few heavy branches, and yields timber for the market in logs of from 20 to 40 feet in length and from 11 to 16 inches square.

The wood is whitish-brown in colour, hard, tough, and flexible, with a fine, smooth, close, silky grain; and as it has only a small quantity of sap-wood it can be worked up closely and economically. It is necessary, however, to remove the sap in the conversion of the log, as, unlike that of the English Elm, it is of a perishable character.

Rock Elm used to be often substituted for the English common Elm for garboards and planking in ship-building, as it is very durable when employed under water; it is also used for ladder steps, gratings, &c., on account of its clean whitish appearance; and owing to its flexible character it is frequently used in boat-building. It cannot, however, be used with advantage in bulk, or even in plank, if exposed to a dry current of air, as under such circumstances it is very liable to split with fine deep shakes from the surface.

Having this serious liability to rend in seasoning,

the logs should never be left a week exposed to the influence of drying winds without some kind of protection, for even less than that time is often sufficient to bring about an amount of deterioration which will greatly affect their value. Therefore, to preserve this timber for future use, it should be treated in the same manner as the English common Elm, namely, by immersing it in water; or, if this cannot be done conveniently, it should be cut into planks of thicknesses which would be available for further conversion if required, taking care to store it in a dry, cool place, under cover, but quite free from draught.

FIG. 24.

The star-shake, in a mild form, is rather common to this description of timber, but does not usually extend to more than 2 or 3 inches from the pith; there is also another, and rather peculiar defect, consisting of several complete consecutive circles of the annual layers being softer and more spongy than the natural or healthy wood (Fig. 24). They are darker in colour, and contain much moisture, and are, as pointed out in Chapter V., p. 63, considered detrimental to the quality, strength, and durability, and consequently, to the value of the tree. The surveyor should, therefore, in selecting this wood take only the logs with a uniform whitish colour for his best work, and leave those which are marked with the dark annular layers upon the ends for inferior purposes.

In all other respects the Canada Rock Elm is a safe wood for the converter to deal with, the instances of defects being found in opening it, arising either from

pruning or from accidental causes, being extremely rare.

Large quantities of this wood are imported annually into each of the London and Liverpool markets, to meet the wants of private dealers, who employ it for coach-making, turnery, boat-building, &c. The Government also used to take about 600 to 700 loads annually for the use of the royal dockyards, stipulating in their contracts that it should be of the first quality, from 11 to 15 inches square, averaging 12½ inches; 20 feet and upwards in length, averaging at least 24 feet in length, and to be well squared, and free from knots.

The Canada Rock Elm is a remarkably slow-growing tree, one of the slowest in fact with which we have to deal; it makes only one inch of wood diameter in about fourteen years.*

TABLE LV.—ROCK ELM (CANADA).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·60	·25	8·55	935	760
2	1·85	·30	8·75	946	753
3	1·75	·30	9·00	899	735
4	1·90	·35	8·65	918	740
5	1·85	·25	8·75	927	738
6	1·55	·30	9·05	895	765
Total . .	10·50	1·75	52·75	5,520	4491
Average .	1·75	·29	8·79	920	748

REMARKS.—All fractured and crippled, but not completely broken asunder.

* See Tabular Statement in Chapter II., on the comparative rate of growth of trees, p. 45.

TABLE LVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 x 2 x 30	740	32,480	8,120
8		738	31,920	7,980
9		765	42,000	10,500
10		753	38,640	9,660
11		735	33,040	8,260
12		760	42,280	10,570
Total . .	...	4491	220,360	55,090
Average .	...	748	36,727	9,182

TABLE LVII.

Vertical or Crushing Strain on cubes of—

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	3·000	15·75	37·125	62·5
17—20	3·125	16·25	36·625	61·0
21, 22	3·500	17·00	—	—
23, 24	3·625	16·00	—	—
Total . .	13·250	65·00	73·75	123·5
Average .	3·312	16·25	36·875	61·75
Do. per in.	3·312	4·062	4·097	3·859

The principal other American Elms are *U. fulva*, the Red Elm, and the "Wahoo" (*U. alata*), both yielding good timber.

AMERICAN WALNUT (*Juglans nigra*).

The wood of the American Black Walnut tree is whitish-brown in colour, moderately hard, straight and plain in the grain, splits freely, and is easy to work; the heart is much darker, however, whence the name, and is very durable and handsome. It will not bear comparison with the quality of either the Italian or Black Sea Walnut wood. The trees are large enough to yield building scantlings, the logs as imported being usually about 15 to 30 inches square, imperfectly hewn, by 10 to 20 feet in length. Owing to the liability of the logs to split from the centre, the ends have generally a red colouring matter put over them before shipment, to protect them against atmospheric influences.

This wood is sold at per foot cube. There is only about ¾ inch of sap-wood on the Walnut trees above mentioned.

The uses of Walnut wood are chiefly for furniture and pianoforte making. It is also much prized for gun-stocks; but there are many other ways of employing it profitably in place of mahogany and other furniture woods.

Other American species of *Juglans* are the Butternut (*J. cinerea*), and the much less important *J. Californica* and *J. rupestris*.

The wood of the Shell-bark Hickory (*Carya alba*) and the Mocker-nut (*C. tomentosa*) and several other species of *Carya* are frequently used in carriage-making, owing to the extreme elasticity of their strong, hard, and close-grained timber.

CANADIAN AND AMERICAN BIRCH.

There are several species of Birch tree in North America, and among the best are the following:—

Betula rubra, or Red Birch, is found on the borders of rivers in the southern provinces of the United States, and according to Michaux, it delights as much in heat as many other species do in cold. It attains the height of 70 feet, with a diameter of 30 to 36 inches. Its uses are chiefly for cabinet work and turnery.

Betula lenta, the Black or Cherry Birch of North America, is, perhaps, the most valuable, and is abundant in the midland states and in Canada. It differs, however, from the common Birch of Europe, and flourishes best in a rich soil. It is of straight growth, and, in favourable situations, attains the height of 75 feet, with a diameter of 30 to 36 inches.

The wood is of a yellowish colour, moderately hard, straight and even in the grain, close in texture, easy to work, and on account of its superior quality to the other species, it is sometimes in America called Mountain Mahogany. American Birch is imported into this country in logs varying from 6 to 20 feet in length, by 12 to 30 inches, pretty well squared, and having only 1 to 2 inches wane upon the angles. The sap is 2 to 4 inches thick.

The heart-shake is small, and the wood near the pith is, for the most part, solid; very little loss can, therefore, arise from its conversion. It is used extensively for furniture, turnery, and in a variety of ways in the domestic arts.

Dark, damp-looking spots and rings are often seen on the ends of the logs, which seem to indicate incipient

and early decay. I imagine, therefore, that it is unsuitable for building purposes.

The specific gravity of European Birch is about 700, and that of American about 600 to 640.

The Yellow Birch (*Betula excelsa*) is a northern and rather large form, with a solid, fine grained, easily worked wood, excellent for cabinet-making.

The Canoe Birch (*B. papyracea*) of Canada and the north states obtains its name from the use of the bark by the Indians. Its white wood is used in turnery, &c.

OTHER AMERICAN TIMBERS.

The Chestnut (*Castanea vesca*) is common in Kentucky, Tennessee, New England, and New York, but the wood is of little importance as compared with that of Italy and South Europe.

Besides our European Beech, there is also a native species (*Fagus feruginea* in the middle states and Canada.

The American Alder (*Alnus incana*) and one or two others yield wood of very little value.

The Sugar Maple (*Acer saccharinum*) of Canada and the northern states, is better known from its sugar-yielding sap than on account of its timber, though fine veneer wood is obtained from it. The same is true of the Black Maple (*A. nigrum*).

The Silver-leaf Maple (*A. dasycarpum*) and the Red Maple (*A. rubrum*) yield soft wood of little value, though that of the latter is used.

Tilia Americana is the Basswood of the Atlantic states and Canada, and its white, light, even-grained wood is much prized for cabinet-work, carving, and fine work.

The timber of the Oregon Maple (*A. macrophyllum*) is

close and fine, and polishes well. There are half-a-dozen other species yielding timber of small size and little value.

The Bow-wood (*Maclura aurantiaca*) of the south-west states is hard and durable, and valued by waggon-makers.

Morus rubra, the Red Mulberry of the Atlantic states, is used in ship-building, and the Hackberry (*Celtis occidentalis*) yields a hard Beech-like timber.

The Tulip tree (*Liriodendron tulipifera*) is a Magnolia, and its soft white wood, known as "White-wood" or Yellow Poplar, is useful for inside work, flooring, &c.

The Button-wood (*Platanus occidentalis*), an ally of which is much planted in Europe under the name of Plane tree, is common in America, and yields a cabinet-wood of considerable beauty. The other Planes are of little or no value as timber.

The Buck-eyes are trees allied to our Horse-chestnut (*Æsculus hippocastanum*), and have soft wood of little value.

The Locust tree, known in Europe as the False-acacia (*Robinia pseudacacia*), has a solid, fine-grained, yellow or greenish heart-wood, of great beauty, and very durable; one or two other species of *Robinia* are known in the United States.

Myall-wood, well known in the manufacture of tobacco-pipes, is obtained from *Acacia homalophylla;* several Australian Acacias also are cultivated in the States.

Various species of *Pyrus* (Pears) yield hard, close woods, useful for carving, but the American species of *Prunus* (Plums) and *Cratægus* (Hawthorn) are of little value as timber.

Several of the Blue Gums (*Eucalyptus*) of Australia are now cultivated in America.

CHAPTER XX.

ASIATIC TIMBERS.

TIMBERS OF INDIA AND BURMAH.

TEAK (*Tectona grandis*).

OF the vast timber supplies of Asia, none are so important to us as those of the Indian Empire, and among these the Teak stands pre-eminent. This tree is found principally in Central and Southern India, and in Burmah; and from the southern limits of its range in Java it is distributed over about 2,000 miles, until it touches close upon the 23° of North latitude. Its range in longitude is also very considerable, since it is found to stretch across Hindustan, and through Burmah to near the frontier of China. It was formerly very plentiful in the Malabar district, but is now only sparingly met with there. At Bombay, where a few years since it was supplied in sufficient quantities from the adjacent province to meet all the demands for ship-building and other purposes, builders have now, owing to its almost complete exhaustion, to draw upon other sources to meet the local requirements. It is now extensively planted, however, in Assam, Bengal, and elsewhere.

The most extensive, and probably the best, forests of Teak at present existing are in Burmah, where they lie spread along the banks of the Salween, Thoungyeen, Irrawaddy, and other rivers. They also stretch very

far inland to the countries occupied by the Shans, the Karens, and the Chinese. Other forests stretch considerably to the north, and there, upon some of the undulating and mountainous districts, it becomes dwarfed to a rather insignificant tree. Teak is also believed to be plentiful in Siam,* and is found on several of the islands in the Indian seas.

The Teak is a deciduous tree, and prefers shelter to bring it to the greatest perfection. In its natural state it grows mixed with Bamboos and other trees. It is of straight growth, and is remarkable for its large drooping leaves, which are from 10 to 20 inches in length, and from 8 to 15 inches in breadth. It frequently attains the height of 80 or 100 feet, with a circumference of from 6 to 10 feet, and yields timber in the log 23 to 50 feet in length and 10 to 30 inches square, these being the sizes commonly shipped to this country.

The wood varies from yellow or straw to a brownish colour; is moderately hard and strong, clean, even, and straight in the grain, and is easily worked somewhat like oak, but very different in structure; it shrinks very little in seasoning, and has no shakes upon the outer surfaces of the log. It will split, however, unless care is

* Since the foregoing was written, a sample of about 200 loads of Teak timber, the produce of Siam, has been imported into London from Bangkok (1873). In dimensions it compared favourably with the Burmah Teak, was quite straight, and of a pale yellowish colour, plain in the grain, moderately hard, and apparently of about the same specific gravity. As a parcel, however, it was faulty at the pith or centre, in having most injurious heart and star-shakes, only about 20 per cent. of the logs being fit for conversion into plank or board; the remainder, owing to the defects referred to, could only be profitably employed in bulk, or reduced to scantlings, which would involve a heavy loss.

The sound and solid wood in the logs, however, was very good; and I am of opinion that if the timber is only carefully sorted over at Bangkok, good shipments might be made for the London market. [Large quantities of excellent Teak are now imported into England annually.—H. M. W.]

observed in applying the fastenings when brought into use. The average weight is not far from 40 lbs. per cubic foot. The quality of the timber depends very much upon the locality in which it is grown, and is exceedingly variable. Teak wood is very fragrant, and contains a resinous oily body which clogs its pores and resists the action of water, and it often oozes into and congeals in the shakes which radiate from the pith, forming there a hard concrete substance which no edge-tool can touch without losing its keenness. This is no doubt due to the calcareous salts deposited in the wood. The oil also acts as a preventive against rust when iron is in contact with it, and for this reason it is preferred to all other known woods for the backing to the armour-plates of iron-clad ships of war. It possesses, indeed, so many valuable properties, that it has long been held in great esteem as a material for construction, while its economical uses are so great, that there is no carpenter, or other worker in wood, who does not, after having once tried it, fully appreciate its value. Its durability is remarkably long, and even the ravages of white ants seem to be resisted by it.

In favourable situations the Teak tree grows to a sufficient height to furnish the lower masts for ships of 2,000 tons burthen, and it is commonly employed for this purpose in the East Indies. Ordinarily the practice is to cut off the bole or stem below the branches; whereas, in many cases, it would be easy to include in it the knots of some of the lower ones, and thus gain a foot or two more of length in the log, which the shipbuilders and many others would consider to greatly enhance its value.

In the late contracts for this description of timber for the royal dockyards, it was stipulated that the minimum

length of the log should be 24, and the average 28 feet, but as of late it has been found difficult to obtain this average from the Moulmein district (whence nearly all our supplies have been drawn for many years past), the minimum and average length has been reduced respectively to 23 and 27 feet.

The Burmese assign two reasons for not aiming to produce a better average length of log; one is that the greater the length the greater is the difficulty of moving and getting them out of the forests to the streams, and the increased danger when there of entanglement in the short bends of the water-courses. Another is that the long logs were, until quite lately, liable to some trifling duty; while upon the short pieces coming from the forests, no charge whatever was levied on their arrival at Moulmein.

It is the practice in Burmah to girdle the Teak trees three years before they intend to fell them; a complete ring of the bark and sap-wood being cut through and removed in order to kill the tree. This object is very soon obtained, as in a few days, or at most a few weeks, the tree is dead; the natural juices contained in it are, therefore, gradually cut off from ascending through the sap-wood while the tree stands. This and the great heat of the climate combined, seasons the wood, and renders the log—which in its green state would have a specific gravity of at least 1·000, and be difficult to move if felled—so much lighter that it floats easily over the shallows of the streams or rivers to the port of shipment. And as usually about a year elapses between the felling and the delivery of the timber in England, it is commonly received in a fit state for immediate use.

The practice of girdling is, I think, objectionable, inasmuch as the timber dries too rapidly, is liable to

become brittle and inelastic, and leads frequently to the loss of many fine trees by breakage in falling; further, it must be regarded as so much time taken from the limit of its duration, which is of great importance.

Girdling has been discontinued in the Annamallay forests of Malabar, under the impression that it causes, or at least extends, the heart-shake. It is, however, practised in Cochin, Travancore, and a few other places; but, as the evidence of its utility goes no farther than to show the advantage gained in being able to float the timber immediately it is felled, it seemed probable that it would eventually be given up entirely. Such, however, is not the case, and it is universally the practice in Burmah to girdle, in order to render the timber floatable. Experiments have been made in Burmah* in felling green Teak, but, as out of 100 trees so felled, twenty-seven in number had extensive heart-shake, and ten others were less seriously affected, it was thought desirable to carry the experiments farther before determining the matter in question.

Although imported and known under the general name of Teak, there are many varieties, if not distinct species of it, the Burmese naming those found in their country after the districts in which they grow; thus, in the Moulmein district there are the Thoungyeen, the Salween, the Karanee, the Attaran, and the Laingbooe Teak; and in the Rangoon district, the Irrawaddy Teak, all differing slightly in colour, grain, texture, and specific gravity.

The Thoungyeen and the Salween Teak timber are of a yellowish-brown colour, smooth and uniform in their texture, with a fine long grain. The Karanee Teak has alternate shades of dull brown and yellow colour,

* Forest Reports.

the grain being close and long, with occasionally a rowiness, or figure, in it, and is also very free from defects. The Attaran Teak is rather stunted in growth compared with the varieties just mentioned, but is of fully the same circumference. The wood is brownish in colour, dense, hard, and resembles very much the Malabar Teak. It is heavier than either the Thoungyeen or Karanee, and is also coarser and more knotty, owing to the branches occurring lower down the stem. Some of these, from accident or otherwise, get broken off, and defects, arising from the moisture lodging in the ruptured parts, are not unfrequent in it.

The Laingbooe Teak has a most peculiar growth, and deviates strangely from the ordinary cylindrical form, in having its stem twisted and deeply grooved, or fluted. It consequently takes a tree of rather large size to yield a small straight square log, and when obtained it is but an indifferent one, owing to the fibre of the grain having been cut and weakened by the hewing of an irregular form or shape into a regular one. In colour this wood is rather darker than any of the others, and it is also considerably harder and heavier.

The Irrawaddy or Rangoon Teak timber is of a pale yellow colour, very closely resembling the Thoungyeen Teak of the Moulmein district in its uniformity of texture, and in having a long straight grain. It is a clean free kind of wood, with the centre commonly softer and more spongy than the outer annual layers. In consequence of this it cuts transversely, with a coarseness and fluffiness of surface near the pith which is remarkable; this, I consider, may be taken as indicative of poorness or inferiority in the quality.*

* The dealers in Rangoon Teak would say that the soft spongy appearance is of no consequence, as it is merely caused by the workmen having

It is also characteristic of the Rangoon or Irrawaddy Teak to be shaky at the centre, there being, besides the heart-shake, which is common more or less to Teak timber, a close, fine star-shake, radiating from the pith, which is seriously detrimental to its value. Many of the logs cannot, therefore, on this account be converted into planks and boards without incurring a very considerable loss. If, however, it is used in bulk, or in stout scantlings, as for backing to armour-plates on ships, or in batteries, or any similar works, it answers equally well with the Moulmein Teak, the risk being in attempting to reduce it into thin planks. The Rangoon Teak is straight, and yields a better average length of log than is to be found in those of the Moulmein district; the dimensions of the squares are, however, nearly alike.

In Malabar, the largest forests of Teak trees are to be found upon the Annamallay hills, at an elevation of about 1,500 to 3,000 feet above the level of the sea. They consist, however, for the most part, of saplings and trees past their prime, the most useful having been felled and removed long since, a few trees of excessively large growth only being left available for the purposes of commerce.

The Teak grown on the Annamallay hills is subject to extensive heart and other shakes about the centre of the tree, and this involves great waste of timber, as only the flitches taken from the outside part are available for use. Attempts have been made to produce "squares" and "planks" by the use of the saw upon pits, and by machinery, but it was found not to answer; the logs were, therefore, cleaved by wedges along the run of the

used a coarse cross-cut saw for butting and topping the logs, in place of an ordinary fine-toothed one, that would be better fitted for it.

heart-shake into two segments, and from these "squares" "planks" and various scantlings were produced by the axe, quite clear of shakes.

The Malabar Teak is very good in quality, and is generally darker in colour, denser, and a trifle stronger than Burmah Teak, when tested, one piece against another. But, as the trees are so much less useful on account of the defects before mentioned, it is probable the Burmah Teak will always have the preference for manufacturing purposes. Malabar Teak is a few pounds heavier per cubic foot than Burmah.*

I tested, when in Burmah, all the varieties of Teak that were then drawn from the Tenasserim forests, and found a very considerable difference in their transverse strength; this, however, may probably be attributed to the variations of soil, and to the length of fibre in the grain.

Thus the transverse strength of the Thoungyeen was proved to be 284 lbs., the Karanee 271 lbs., the Attaran 201 lbs., and the Laingbooe only 175 lbs. per square inch, the mean strength being 233 lbs. per square inch. The several specimens tried were each of them 2 x 2 x 84 inches, supported on props six feet apart, with the weight applied, as usual, in the middle; the result being that the Thoungyeen and the Attaran both broke with a long splintery fracture, while the others snapped off very short.

In some experiments more recently conducted in this country on twelve pieces of Moulmein Teak of the

* An effort has recently been made to open up afresh the resources of the Annamallays; but owing to the faulty character of the trees, and from having to convey the logs a distance of about forty miles by land-carriage to a port of shipment, it is thought to be extremely doubtful whether it can ever compete in the European market with the Teak timber of Burmah.

same dimensions as above, the results gave, as the mean breaking weight, 220 lbs. to the square inch, which is less than the average of the four varieties just mentioned, and 32 lbs. below the average of the three first-named; the Laingbooe being struck out as not likely ever to be imported in sufficient quantities to affect the results when applying Teak to building purposes. The difference is against the specimens tried in England, but this may be attributed mainly to the more seasoned state of the pieces, and, perhaps, in part, to better appliances for testing.

The mean deflections of the twelve pieces referred to were, when weighted to 390 lbs., 1·791 inch, and with the breaking weight of 878 lbs., 5·916 inches. From these results it appears, by the application of the formulæ used by Professor Barlow, that the strength is represented by 2303, and the elasticity by 530970. The same pieces being tested for tensile strength, took a strain nearly equal to 6 tons to overcome the direct cohesion, or about 3,301 lbs. to the square inch.

A number of cubes of this timber were subjected to a crushing force in the direction of the fibres, and these generally gave way under a pressure of about 2½ tons per superficial inch of base. Altogether, some fifty-three experiments of this kind were made upon Teak, four being on pieces 2 × 2 of various lengths, others were 3 × 3, varying by 1 inch from 8 to 18 inches in length, the piece of 16 inches proving to be the strongest, and taking 28·75 tons to crush it; then there were pieces 4 × 4, and severally varying by 1 inch from 15 to 24 inches in length, the piece of twenty inches proving to be the strongest, and taking 42 tons to crush it. Again, there were pieces 6 × 6, and severally varying by 3 inches from 12 to 30 inches in length, the piece 18 inches in

length taking 174 tons to crush it; and finally, there were other pieces 9×9¼, varying by 3 to 6 inches from 12 to 30 inches in length, the strongest of which, 21 inches in length, took 368·6 tons to cripple it; the details of these will, however, appear in Tables LXII. and LXIII.

The following experiments were made in order to test the deflections of Teak under given weights at various distances, viz:—

TABLE LVIII.

Nos. 1 to 6.

Specimen, 2 × 2 × 84 inches, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300 lbs., the deflections were	·065	·300	·750	1·250 ins.
„ „ 400 lbs., „ „	·300	·600	1·150	2·050 „

Specimen, 2 deep × 1½ broad × 84 inches, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300 lbs., the deflections were	·300	·400	1·100	2·100 ins.
„ „ 400 lbs., „ „	·400	·800	1·500	2·800 „

This piece, tried the other way, viz.:—

1½″ deep × 2″ broad, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300 lbs., the deflections were	·200	·800	1·600	3·200 ins.
„ „ 400 lbs., „ „	·500	1·200	2·600	Broke.

The specific gravity of these pieces was respectively ·586 and ·631; a proof that they were thoroughly seasoned. Upon the laws which govern these deflections, I offer no opinion, and the experiments are merely introduced here to show how near the results go to confirm

Professor Barlow's theory that the strength varies as the cubes of the length.

There is one other species of trial which it may be well to mention, namely, that to ascertain the elongation of the fibres of Moulmein Teak in a length of 3 feet under certain strains. Three pieces, each $2 \times 2 \times 48$ inches, were thus tested, at one of the royal dockyards, and it was found that the mean elongation was nearly a quarter of an inch. (See Table LXIV.)

The Teak tree is subject to a wasting away of the early annual layers long before it reaches maturity; and the number of young trees found thus affected in the rafts brought from the forests to the shipping port is very remarkable. The surveyor judging only from the deliveries of Teak in this country would hardly be aware of this, as hollow trees would not be selected for the European market.

Teak timber is also subject to heart-shake, as before observed, and in many logs, especially if they are procured from old trees, it is found to extend to one-half, and sometimes to two-thirds the diameter of the tree, and stretching along the entire length of it. If this shake is in one plane throughout, the conversion of the log involves no greater difficulty or loss than that occasioned by dropping out a piece large enough to include it. When, however, as in other instances, the cleft or shake at the top is at right angles, or nearly so, to that at the butt-end, it is rather more serious, as the log must either be used in its greatest bulk, or worked up for small scantlings, such as could be obtained if it were cut into two or more lengths.

If the shake extends only a few feet up from the butt-end, the most profitable way of converting the log would be by cutting it into plank or board, taking care to work

from the outside instead of the centre, and thus waste only a tapering or wedge-like piece, sufficient to include the defect.

Many Teak logs are worm-eaten; holes from a quarter to half an inch in diameter are found upon the surface, which often penetrate deeply and in all directions. Such logs have generally a dull appearance, and are invariably brittle and of inferior quality. This defect is, I consider, indicative of the tree having been unhealthy if not dead before it was cut down.

The ravages of the worm are detrimental to the strength and value of the timber, and logs so affected are not fit to be reduced to plank for use on bottoms of ships.

Teak, notwithstanding its defects, is extensively used for ship-building in this country, in place of English and other Oaks, African and Sabicu timber, &c., &c., and the objection that was formerly made against its use in ships of war, as being unsuitable, on account of its liability to splinter if struck by a shot, is no longer allowed to stand in the way of its employment.

Teak timber is also used, to a moderate extent, for ship-building in the arsenals of foreign countries. Its employment for construction, railway carriages, and sleepers, ship-building, &c., is well known.

The quantities of Teak timber received here annually from Moulmein have hitherto been very large, and so greatly in excess of that which it was calculated a few years ago could be drawn from the Tenasserim forests, that fears have been entertained the supply from that source must soon fail, and we notice a falling off in the shipments. This has, however, been supplemented by the shipment of considerable quantities of Teak from Rangoon, and it seems probable that that port will soon

become the chief timber station for the export of this important article of commerce.*

I do not, with this new source of supply open to us, apprehend that any serious difficulty is likely to arise for some time to come; but, happen when it may, there are yet the forests of Siam, which are said to be very extensive, and also those of Java, almost untouched; and from these, I imagine, the future supplies for the European market could be drawn.†

Teak timber is sorted into A, B, and C classes in the London market, according to dimensions, not quality, A class or pile being 15 inches and upwards on the larger side, and 23 feet and upwards in length; B, ditto ditto, 12 and under 15 inches on the larger side, and 23 feet and upwards in length; C, ditto ditto, under 12 inches on the larger side, and 23 feet and upwards in length; D are damaged logs. B and C classes are usually sold at about 10 to 20 shillings per load under the price for A pile timber.

The value of Teak in the London market has fluctuated very much. In 1859 and 1860, the market being overstocked, it stood as low as £10 to £11 per load of 50 cubic feet; but in 1861, when there was a sudden and unexpected demand for timber generally, it rose to £16 per load; it soon, however, declined again, and in 1875, with a stock of about 8,000 loads of Moulmein and Rangoon upon hand in the London market, was to be had at about £12 to £14 per load. It is now about £15 to £17 per load.

* Between 1865 and 1870, inclusive, Moulmein sent to Europe 147,421 loads, and Rangoon 28,821 loads of Teak timber. The shipments are now much larger.

† The prediction that Siam would yield abundance of Teak has since turned out to be correct. Moreover, the Indian Forest Department plant several thousand acres annually, so that little fear of short supplies need be entertained, especially as natural reproduction goes on extensively in the protected areas.

TABLE LIX.—BURMAH (OR MOULMEIN) TEAK.—NO. 1.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
7	2·05	·25	5·50	840	712
8	1·35	·10	4·50	971	787
9	1·75	·15	4·75	867	840
10	1·65	·00	5·00	915	724
11	1·75	·00	7·50	923	720
12	1·35	·00	5·00	960	874
Total . .	9·90	·50	32·25	5,476	4657
Average .	1·65	·083	5·375	912·66	776·16

REMARKS.—Each piece broke short to the depth of about one-third, then with scarph-like fracture, 8 to 12 inches in length.

TABLE LX.—BURMAH (OR MOULMEIN) TEAK.—NO. 2.

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
13	1·25	·0	5·25	950	910
14	2·10	·0	7·00	850	821
15	1·75	·0	7·00	920	805
16	1·90	·0	6·75	816	790
17	1·50	·0	6·50	920	800
18	3·15	·5	6·25	602	726
Total . .	11·65	·5	38·75	5,058	4852
Average .	1·942	·083	6·485	843	808·66

REMARKS.—Each piece broke short to the depth of about one-fifth, then with scarph-like and fibrous fracture, 10 to 14 inches in length.

TABLE LXI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
19	2 × 2 × 30	787	14,564	3,641
20		800	16,240	4,060
21		724	10,916	2,729
22		805	14,000	3,500
23		726	10,368	2,592
24		821	13,152	3,288
Total . .	...	4663	79,240	19,810
Average .	...	777	13,207	3,301

TABLE LXII.

Vertical Experiments on Cubes of

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
25 to 28	2·375	12·500	23·75	37·5
29, 30	2·500	12·500	—	—
31, 32	2·625	10·750	—	—
33, 34	2·500	10·500	—	—
35, 36	2·125	10·750	—	—
37, 38	2·375	11·125	—	—
Total . .	14·500	68·125	—	—
Average .	2·4166	11·354	23·75	37·5
Do. per in.	2·4166	2·838	2·64	2·343

TABLE LXIII.

Vertical Experiments.

Number of the specimen.	Dimensions of the pieces. Inches.	Length. Inches.	Specific gravity.	Crushed with Tons.	Ditto on the square inch. Tons.
39	2 × 2	1	760	13·750	3·437
40	2 × 2	2	730	11·354	2·838
41	2 × 2	3	770	12·875	3·219
42	2 × 2	4	780	13·750	3·437
43	3 × 3	8	744	18·000	2·000
44	3 × 3	9	704	18·500	2·055
45	3 × 3	10	653	18·000	2·000
46	3 × 3	11	663	18·250	2·028
47	3 × 3	12	640	19·000	2·111
48	3 × 3	13	635	20·000	2·222
49	3 × 3	14	672	23·500	2·388
50	3 × 3	15	678	23·750	2·639
51	3 × 3	16	672	24·250	2·694
52	3 × 3	17	678	24·000	2·666
53	3 × 3	18	661	22·500	2·500
54	4 × 4	15	662	33·5	2·094
55	4 × 4	16	682	34·0	2·125
56	4 × 4	17	724	38·25	2·387
57	4 × 4	18	744	40·25	2·515
58	4 × 4	19	699	37·00	2·312
59	4 × 4	20	756	42·00	2·625
60	4 × 4	21	761	40·25	2·515
61	4 × 4	22	771	37·00	2·312
62	4 × 4	23	690	37·50	2·343
63	4 × 4	24	644	30·00	1·875
64	6 × 6	12	811	153·0	4·250
65	6 × 6	15	831	163·8	4·550
66	6 × 6	18	831	174·0	4·833
67	6 × 6	21	786	169·0	4·694
68	6 × 6	24	836	122·2	3·399
69	6 × 6	27	693	168·4	4·666
70	6 × 6	30	781	153·0	4·250
71	9 × 9	12	889	307·0	3·776
72	9' × 9'	15	845	337·8	3·974
73	9 × 9	18	846	286·0	3·530
74	9' × 9'	18	864	307·0	3·612
75	9' × 9'	21	828	368·6	4·572
76	9 × 9	24	757	276·2	3·410
77	9 × 9	30	835	307·0	3·790

TABLE LXIV.

Experiments on Specimens of Teak, to ascertain the elongation of the fibres in a length of 3 *feet, under various strains, the dimensions of each piece being* 2 × 2 × 48 *inches.*

Number of the specimen.	2 Tons.	3 Tons.	4 Tons.	5 Tons.	6 Tons.	7 Tons.	8 Tons.	9 Tons.	10 Tons.	Elongation preceding rupture.	Breaking strain.
										Inch.	Tons.
78	1/32	1/16	2/32	2/16	5/32	3/16	...	...	...	3/16	7·75
79	1/32	1/16	3/32	3/32	2/16	3/16	3/16	4/16	5/16	5/16	10·25
80	...	1/32	1/16	2/16	3/16	...	...	...	...	3/16	7·00
The mean.	·0313	·0521	·0729	·1145	·1249	·187	·187	·25	·312	·229	8·333

CHAPTER XXI.

ASIATIC TIMBERS—INDIA AND BURMAH—(*Continued*).

THE *Pyengadu*, or Iron-wood* tree of Pegu and Arrowcan, the *Xylia dolabriformis* of the botanists, is a species allied to the Acacias, of straight growth, found in the Burmese South Indian forests, and also in the country occupied by the Karens, towards Western China, where it is often seen rising to 70 or 80 feet clear of branches, and of very large circumference. It yields timber in the log 12 to 24 and even 30 inches square, and of great lengths.

The wood is of a reddish-brown colour, hard, heavy, tough, strong, rigid, and frequently possesses some figure in the grain, which has the appearance of being both waved and twisted; its pores are filled with a remarkably thick glutinous, oily substance, which oozes out

* Iron-wood is a name loosely applied, for obvious reasons, to many different timbers in various parts of the world; perhaps the name is best deserved by the species of *Sideroxylon*, but it is also given to species of *Diospyros* and *Metrosideros*. The following are the chief examples of trees of other genera which go by this name in different countries: Burmah, *Xylia dolabriformis*; India and Ceylon, *Mesua ferrea*; Australia, *Acacia stenophylla*, species of *Eucalyptus*, *Melalenca*, *Myrtus*, *Notelæa*, &c. In North America species of *Ostrya* and *Olneya* go under this name; in Natal, *Olea laurifolia* and *Toddalia lanceolata*; in the Straits Settlements and Borneo the Billian is so called. The Iron-wood of Persia is *Parrotia persica*; that of the West Indies *Sloanea jamaicensis* and species of *Fagaria*. That of British Honduras is *Laplacea Hæmatoxylon*.

upon the surface after the wood has been worked, leaving a clamminess which cannot be completely got rid of until the piece is thoroughly seasoned. This oily substance has probably a preservative property about it, and may be conducive to the durability of the timber, which is very great.

The *Pyengadu* was highly spoken of by the officers at Moulmein, who supplied considerable quantities of it to the Madras Government for the manufacture of gun-carriages, and also for other purposes. Although it was not extensively known then, it was a favourite wood in the East for works requiring strength and durability, and without doubt the samples I met with all looked remarkably well, and seemed fit to be employed in any work of construction where great strength is required.

It is interesting to note that, subsequent to this, Lieut.-Col. H. W. Blake, the Commissioner at Moulmein, brought this wood to the notice of the Home Government. He says: "It is one of the largest trees in Burmah, and is called *Ingazylocarva,* a species of Acacia, which combines in itself the properties of wood and iron, and is therefore very appropriately called Iron-wood by us and *Pyengadu* by the Burmans. It is heavier than water and more indestructible than iron. There is a piece of this wood which supported a Teak figure of 'Godama' taken from Rangoon in 1826, standing in a lake near. The Teak figure has long since mouldered away into dust, but at the pillar I fired a rifle shot, at 20 yards' distance; the ball was thrown back, making no penetration whatever. The wood seems hardened by time and exposure, and it is also a fact that the teredo will not touch it. The Burmans do not girdle and kill this tree as they do the Teak, but fell and saw it up at once, and refuse to work it in a dry state."

Dr. Hooker says: "It is found, not universally in India, but in widely distant parts. Throughout Tenasserim and the Malay peninsula it is called 'Peengado.' It is abundant in the Bombay Presidency, where it is called 'Jambea' and 'Yerool;' in the Godavery forests it bears the name of 'Boja;' it is common at Singapore, and I have ascertained that it is plentiful in the Philippine Islands. Everywhere the wood bears a high character for hardness and durability; the white ant will not touch it; it shrinks in seasoning one-eighth inch per foot of surface, and the density is 5 lbs. 10 oz. per foot superficial. It is one of seven or eight species of trees which Dr. Falconer, in his report of the Teak forests of Tenasserim, earnestly requests the Indian Government to preserve."

Five specimen logs of the Pyengadu, each about 20 feet in length, and 20 to 24 inches square, were sent to Woolwich Dockyard in 1863, for trial experimentally in ship-building; but, as they were found to have extensive heart-shake, they were scarcely fit for constructive purposes. If, therefore, the heart-shake defect seen in these logs fairly indicates the character of this wood, its value as building timber would be seriously affected. I am, however, of opinion that this is not the case, and that these were probably some chance pieces which happened to be in the way when specimen logs were required. Three of the logs here referred to were kept for several years at Woolwich without any good opportunity offering for their employment, and after this lapse of time they did not appear to have undergone any change, or to be in the slightest degree deteriorated.

The specific gravity of these logs was about 1176, while that given by Dr. Hooker is 1080; the difference is therefore not very important.

TABLE LXV.—IRON-WOOD, OR PYENGADU (BURMAH).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	·75	·00	4·50	1,240	1150
2	1·00	·05	4·60	1,250	1225
3	1·00	·05	4·90	1,490	1150
4	·85	·00	3·25	1,110	1165
5	·90	·00	3·50	1,130	1225
6	1·25	·10	4·75	1,420	1143
Total . .	5·75	·20	25·5	7,640	7058
Average	·958	·033	4·25	1273·3	1176·33

REMARKS.—Nos. 1, 2, 3, and 6 broke with about 12 inches length of fracture, 4 and 5, with somewhat less. All were fibrous and wiry.

TABLE LXVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1143	35,840	8,960
8		1150	41,440	10,360
9		1150	40,320	10,080
10		1225	38,640	9,660
11		1165	38,080	9,520
12		1225	37,420	9,355
Total . .	...	7058	231,740	57,935
Average .	...	1176	38,623	9,656

TABLE LXVII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 13.	No. 14.	No. 15.	No. 16.	No. 17.	No. 18.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
20·750	20·625	20·875	20·500	21·250	21·000	125·000	20·833	5·208

THE INDIAN OAKS.

The number of Indian Oaks, belonging to the same genus (*Quercus*) as the European and American forms, is considerably larger than was formerly supposed, and much information is still required about their timber. As a rule, the general structure of the timber, and the colour of the heart-wood, resembles our native Oaks in many respects, but there are considerable differences in the details as to the medullary rays, and especially the annual rings, which in many forms are so indistinct as to give the impression that no periodic growth is marked.

Many of the Indian Oaks yield much harder and heavier timber than our native species, and in these cases there is an objectionable amount of warping and cracking during the seasoning. Others, again, and especially those with narrower medullary rays, season well.

The following are the principal, and it will be noted that they all belong to the more Northern and colder higher districts of India. They may be roughly divided according to the localities where they grow, and are worked.

Quercus semecarpifolia occurs along the whole Himalayan range, or nearly so, at 8–10,000 feet, from

Afghanistan in the North-West to Bhotan in the East, and yields large timber of a reddish grey hue, very hard, and used for all kinds of building work.

Q. incana has roughly the same distribution in longitude, but grows at a lower altitude, 3–8,000 feet, and has a browner and even harder heart-wood which warps and splits a good deal, rendering it difficult to season and work. This is also used for building to some extent.

The chief Oaks of the North-Western regions are *Q. dilatata*, yielding large timber which, though hard, seasons well and does not warp, is durable and used for building purposes; and *Q. Ilex*, the Holm Oak or Ilex of Southern Europe, used for minor purposes.

The Darjeeling Oaks grow in the Eastern Himalayas and are chiefly *Q. pachyphylla*, with a very durable greyish timber, and the commonest Oak of the higher elevations (8–10,000 feet), where it is used for planking, palings, shingles, &c.; *Q. annulata*, with handsome and well-marked, but not very durable wood; *Q. lamellosa*, with similar timber showing splendid "silver-grain," and much employed for all kinds of building and construction, but not so durable as *Q. pachyphylla* if exposed to damp. *Q. lappacea* grows in the Khasia Hills, and it and *Q. lanceæfolia* are not much used.

Q. fenestrata grows in Burmah, and is used for building in the Khasia Hills, and *Q. spicata* is similarly employed in Assam.

Q. Griffithii has a very hard, brown wood, much like that of strong English Oak, and is used in the Khasia Hills; and *Q. serrata* resembles it in most respects.

Quercus lanuginosa and *Q. acuminata* are interesting, but their timber is not much employed except as firewood.

THE SAL (*Shorea robusta*).

This is one of the most important trees of India, found growing gregariously in the North-East and intermediate moist regions, the sub-Himalayas, Assam, &c. It has a small, whitish, and almost useless sap-wood, and a deep brown, hard, fibrous, and cross-grained heart, weighing between 50 and 60 lbs. per cubic foot. Although it warps and splits on seasoning, this wood is almost unrivalled for strength, elasticity, and durability, and is extensively used throughout Northern India for piles, works of construction, and particularly for sleepers. Unfortunately it is so difficult to float that its extraction is costly. It abounds in aromatic resinous substances, which no doubt enhance its durability. It is a pity this and other Indian species of *Shorea* and the allied genera *Dipterocarpus* and *Hopea* are not better known in Europe, as their qualities are thoroughly appreciated in India.

THE SISSOO (*Dalbergia Sissoo*)

is one of the most valuable of Indian timbers where strength and elasticity are required. It is a large deciduous tree of the sub-Himalayan tract, with dark brown, veined heart-wood of close texture, and very hard and heavy. It seasons well, without warping or splitting, and is very strong, elastic, and durable. It is extensively employed for all kinds of construction and building work in North India, and has stood the severest tests as material for wheels of ordnance carriages. It should also be valuable for carving. Unfortunately it is not so easily procurable in quantity now as it used to be.

Dalbergia latifolia, the Blackwood or Rosewood of Southern India, is a closely allied timber-tree of the

South, Central, and Bengal districts, with purple-streaked heart, but somewhat hard to work, owing to its tough cross-grain. It is an extremely beautiful furniture wood, and has fetched high prices in Europe, where it has been exported from plantations in Malabar and Kanara. It has also been recommended for parquet work. Excellent sleepers have been made from it in Mysore.

PADOUK, OR ANDAMAN RED-WOOD,

is the timber of *Pterocarpus indicus*, a tall leguminous tree of Burmah and the Andaman Islands. The dark red, close-grained heart-wood is hard, and slightly aromatic, and works fairly well. It is reported to be the most useful wood of the Andamans, and valuable for furniture and other cabinet work, and is highly recommended for railway-carriage work, resembling Teak in some respects. It has fetched excellent prices in Europe.

P. santalinus, the Red Sanders Wood, is from an allied tree of South India, and commonly employed for dyeing. *P. Marsupium* should also be noted as a useful and handsome timber of Southern and Central India.

THE TOON OR THITKADO (*Cedrela Toona*).

Of a less useful character, but still of considerable value, is the Thitkado, the Toon of India (*Cedrela Toona*), a kind of bastard Cedar, which yields timber 11 to 26 inches square, and 14 to 40 feet in length.

The wood is of a pale red colour, clean and straight in the grain, moderately hard, and not difficult to work; it is very fragrant and durable, and is often known as Moulmein Cedar. It is not a true Cedar, in the

botanical sense, but is a large tree of the natural order *Meliaceæ* growing in the forests of the lower Himalayas, Bengal, Burmah, and South India. It is not mild enough for pattern-making, but, for general purposes in the domestic arts, it might be used in lieu of the better kinds of Cedar from Cuba and Mexico, whenever these are scarce in the market.

The Thitkado is subject to heart and star-shakes, and in seasoning is very liable to split from the surface if left long in the round or unconverted state, consequently we need not look for any very extensive business to be done in it. There have been some importations of this wood into the London market, and to the Continent. It is very valuable as a furniture and cabinet wood, and has been for some time used in Bengal and Assam for making tea-boxes, but the demand exceeds the supply, and large trees are scarcer than formerly. This Moulmein Cedar must be distinguished not only from the true Cedars (*Cedrus*) but also from the Bermudan Cedars (*Juniperus*), both of which are coniferous woods belonging to the Pine and Fir family. In many respects the wood of *Cedrela* resembles that of Mahogany.

EBONY.

The Ebonies of India are yielded principally by the following trees: *Diospyros Melanoxylon*, throughout India proper, and *D. Ebenum* of South India and Ceylon; *D. Kurzii* is the beautiful Andamanese Marblewood, one of the handsomest timbers in the world.

The true Ebony, obtainable in fairly large masses and very heavy and difficult to extract and work, is the heart-wood of *D. Ebenum*. This is a large tree with a

grey sap-wood and very irregular, jet-black, solid heart, sometimes streaked with lighter markings. The Indian forest officers say the demand for it is not great, but it is much used for inlaying and turnery work. The weight often exceeds 70 lbs. to the cubic foot, but its other properties, as well as its structure, require further examination. Beautiful carving is sometimes executed in this wood, which is capable of taking a very high polish.

D. Melanoxylon has a pink sap-wood, with irregular black heart, and is very hard. It usually has beautiful purple streaks in the black mass, and is heavy and strong. All the wood is used for building, shafts, carving, and fancy work.

The handsome Marble-wood of *D. Kurzii* ought to be much more largely imported than is at present the case. *D. quæsita*, the Calamander wood of Ceylon, is now getting scarce; it is one of the most valuable ornamental woods of Ceylon and South India. There are several other Ebonies in India, but far too little is known of them and their uses at present.

OTHER INDIAN TIMBERS.

Of the numerous other woods employed for purposes of construction, etc., in the Indian Empire, the following may be noted as the chief:—

Dillenia indica, the Chalta, a large evergreen tree of Bengal, Central and South India, and Burmah, yielding a fine red mottled wood; and *Dillenia pentagyna*, with reddish grey timber.

Michelia Champaca, the Champa, principally Northern India, with a durable, soft, olive-brown heart, very useful in building.

Calophyllum inophyllum, an evergreen of South India

P 2

and Burmah, with a red-brown, fairly hard and close wood, used for sleepers, &c.

Mesua ferrea, the Iron-wood of Eastern Bengal, Assam, South India, and Burmah, and one of the hardest of timbers. If not so difficult to work it would rival *Pynkado* for sleepers.

Schima Wallichii, a rough, red, and very durable timber of Bengal, which has been much used for bridges and sleepers.

Thespesia populnea, a moderately hard wood of the Indian coasts and Burmah, used in carriage and cart work, &c.

Bombax malabaricum, the "Cotton Tree" of India—not to be confounded with the true Cotton Tree, however—with a very soft light wood, used for packing-cases, floats, &c.

Heritiera littoralis, the Sundri of the tidal forests of Bengal, Burmah, &c., with an extremely hard and heavy dark red, close-grained wood, very durable and used for boat-building. It is the chief timber of the Sunderbunds, and is extensively employed in Calcutta.

Melia indica, the Neem or Margosa of India, has red hard wood, used for furniture; and *M. Azedarach*, the "Persian Lilac," has a softer, beautifully marked wood of great use in cabinet work.

Swietenia Mahogani is the Mahogany, a large evergreen tree, introduced from Jamaica and Central America into India in 1795, and now cultivated in Bengal and Burmah.

Acer Campbellii is a Himalayan Maple extensively used for planking, tea-boxes, &c., in the North-East, and *A. pictum* is used in the North-West.

Pistacia integerrima, the Pistacio Nut, and the Mango (*Mangifera indica*) yield timbers used in India, but

these trees are more valued for their fruits; the same applies to *Anacardium occidentale*, the Cashew Nut.

Gluta travancorica, a tree of the ghats of Tinnevelly and Travancore, yields a very beautiful dark red timber, with fine markings and capable of taking a high polish. Though very little used, it ought to make a splendid furniture wood.

Buchanania latifolia and *Odina Wodier* are allied species, also probably worth notice by the trade. The same is true of the very ornamental, purplish-black wood of *Milletha pendula*, and the mottled-brown wood of *Ongeinia dalbergioides*.

Erythrina suberosa is remarkable for its very soft and light, almost pith-like wood.

Other Indian Leguminosæ worth noting are *Cæsalpinia Sappan* with very red timber, but not large; *Bauhinia racemosa*, scarcely known; *Tamarindus indica*, cultivated throughout India and Burmah and highly prized for turning, &c., but hard to work. The same applies to *Hardwickia binata*, a dark red wood of South and Central India, and perhaps the hardest and heaviest wood of the country.

Acacia Arabica is one of the commonest trees throughout India, and its pinkish to brown, hard, mottled heart-wood is extensively used for all kinds of purposes. If properly seasoned it is very durable; but as the trees are not large it cannot be obtained in pieces of more than moderate dimensions.

Acacia Catechu, a common tree of India, has been used for sleepers, and one or two Australian species of *Acacia* are planted. *Albizzia Lebbek*, *A. procera*, and *A. odoratissima* are also used.

Prunus Puddum, of Sikkim and the Himalayas, probably deserves to be better known. *Bucklandia*

populnea is used for planks in Darjeeling; *Carallia integerrima* for furniture in Kanara and Burmah.

Terminalia belerica, a large tree of North India and Burmah, yields a timber much employed in these regions, and *T. chebula* and *T. tomentosa* are also used. But the chief value of these trees is on account of the tannin in their fruits (Myrobalans). *T. bialata* has also been well reported upon.

Anogeissus latifolia, a large tree of the Indian Peninsula, has a hard purple heart, but much grey or yellowish sapwood. It is very strong and tough, but splits on seasoning, and is only durable if kept dry.

Eugenia Jambolana, found throughout the Indian Empire, yields a fairly durable, reddish-grey, moderately hard wood, and has been well reported upon by railway engineers. *Carreya arborea* is a large tree of Bengal and Burmah and other parts, with a somewhat claret-coloured, beautifully mottled timber, durable, but far too little known at present.

Lagerstrœmia parviflora, of Oudh, Bengal, Assam, Central and South India, has a greyish-brown, very tough and elastic wood, workable, seasons well and durable for sleepers. The allied *L. Reginæ*, of East Bengal, Assam, Burmah, and the West Coast, has a light red, hard, lustrous timber, which is probably second only to Teak. It is largely used in construction and shipbuilding, &c., and deserves to be far better known.

Adina cordifolia is also a useful yellow wood, used throughout the moister parts of India and Burmah. *Bassia latifolia* and *B. butyracea* may also be mentioned, though their timber is little used, owing to the economic value of the flowers and fruit.

Alstonia scholaris, a not very durable timber, is used

for soft work in Bengal, Burmah, and the South of India; and *Holarrhena antidysenterica* for furniture and carving. Both yield white, soft, and even-grained timber.

Fagræa fragrans, the Anan, is a Burmese evergreen tree, with a hard, red-brown, close-grained, and beautifully mottled timber, very durable and resistent to *Teredo*. It is one of the most important trees of Burmah, and is much employed in bridge and boat work.

Gmelina arborea, the Gumbar of Bengal, and closely allied to Teak, is found throughout India and Burmah, and yields a greyish wood with yellow or pink shades, glossy, close, and even, light, but strong and durable, and seasons without warping or cracking. It is extremely good under water, and is highly prized for planking, panelling, boat work, carving, &c., and is the chief furniture wood of Chittagong and well known in Calcutta.

Santalum album is the Sandal wood, a small tree of Mysore, and of the drier parts of India. Its yellow-brown heart is strongly scented, and valuable for fancy work.

Artocarpus Chaplasha, and other species of the same genus, and various species of the allied Figs (*Ficus*), are employed in various parts of India, chiefly for minor work. The same is true of *Ulmus Wallichiana* and *U. integrifolia*, two Himalayan Elms; and of *Betula Bhojpatra*, a native Birch.

There are found in the Commissariat Stores at Moulmein, besides the Teak and Pyengadu, many other valuable woods of building sizes, and the following are especially worthy of notice, namely, in addition to the Padouk (*Pterocarpus*) of a deep red colour, the Parewah,

and the Penthityah, both of a dark reddish-brown colour; the Kammone; the Anan (*Fagræa fragrans*), and the Kamonpew, each reddish in colour, but rather paler than the Padouk. There is also the Thingan (*Hopea odorata*), a wood heavier than Teak, and which lasts under water far better. It grows abundantly on the Tavay coast and islands.*

The above are all very compact woods, close and fine in texture, of good quality, and no doubt durable. They have long been in use in Burmah, and in the Madras Presidency, and are fit and suitable for use in works of construction, but, up to the present time, they are scarcely known in this country.

Small quantities of Thitka or Kathitka, a kind of bastard Mahogany, have also been exported from Burmah, for furniture and other purposes, but I have not yet met with it in London. It is thought to be a species of Tiliaceæ, and is named by Kurz as *Pentace Burmanica*.

* Report of the officiating Inspector General of Forests.

CHAPTER XXII.

ASIATIC TIMBERS (*Continued*)—TIMBERS OF BORNEO AND THE CHINA SEAS, ETC.

AMONG the vast quantities of Asiatic timbers, most of which are as yet inaccessible to British commerce, the following are worthy of note:—

The Chow, or Menkabang Penang tree, is found in the Island of Borneo, where it is said to be very abundant. It attains large dimensions, is of straight growth, and yields timber in the log of from 30 to 70 feet in length, and from 15 to 26 inches square.

The wood is of a yellowish or straw colour, close and fine in texture, straight in the grain, hard, heavy, tough, and exceedingly strong. It is used in Borneo and the countries bordering on the China seas, for the masts of junks and other vessels, for house and ship-building, and for a variety of minor purposes.

The earliest importation of the Chow, or Menkabang Penang timber, into this country was, I believe, in 1860–61, when it came direct to the London market, and thence passed into Woolwich Dockyard, to be experimentally employed for beams, keelsons, and other purposes where strong, straight timber is required in ship-building; and in this way it gave every satisfaction.

One or two cargoes of Borneo timber, including the Chow, subsequently reached this country, and were delivered at the northern ports, where they were gradually absorbed, chiefly in ship-building; but, owing to the more extended use of iron in ships, the wood is

not now inquired for, and the importations appear, for a time at least, to have ceased.

TABLE LXVIII.—CHOW, OR MENKABANG PENANG (BORNEO).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·00	·00	2·75	904	1144
2	1·00	·05	4·10	1,231	1100
3	1·00	·00	1·75	766	1136
4	·75	·05	3·50	1,122	1124
5	1·00	·05	2·65	814	1070
6	·75	·00	2·25	1,013	1120
Total . .	5·50	·15	17·00	5,850	6694
Average .	·916	·025	2·833	975	1115·6

REMARKS.—Nos. 1, 2, 4, and 6 broke with fractures about 12 inches in length; 3 and 5, rather shorter.

TABLE LXIX.
Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1100	25,760	6,440
8	2 × 2 × 30	1136	25,760	6,440
9	2 × 2 × 30	1144	31,640	7,910
10	2 × 2 × 30	1170	31,360	7,840
11	2 × 2 × 30	1120	29,456	7,364
Total . .	...	5670	143,976	35,994
Average .	...	1134	28,795	7,199

TABLE LXX.
Vertical or Crushing Strain on cubes of 2 inches.

No. 12.	No. 13.	No. 14.	No. 15.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons	
22·750	22·500	22·250	22·446	89·946	22·486	5·621

THE PINGOW TREE

is also found in the island of Borneo, where it is said to be plentiful. It is of straight growth and good dimensions, and yields timber of from 25 to 40 feet in length, and 11 to 18 inches square.

The wood is of a dark brown colour, hard, heavy, tough, rigid, and remarkably strong; it is straight in the grain, close in texture, and not difficult to work. It is used in Borneo for all the purposes to which the Chow is applied, except that, as the tree does not attain the same altitude, it will not furnish masts for any but the smaller junks. The characteristic properties of the Pingow are favourable to its introduction for any purpose where great strength is required; and, of the sample logs brought to this country in 1860–61 and at subsequent dates, the whole were passed either to Woolwich Dockyard or to the out-ports, to be employed in ship-building.

TABLE LXXI.—PINGOW (BORNEO).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·05	3·50	1,235	757	1631	308·75
2	·75	·05	3·65	1,223	753	1624	305·75
3	·65	·00	4·25	1,355	745	1819	338·75
4	·90	·10	3·75	1,237	742	1667	309·25
5	·75	·15	4·35	1,302	748	1740	325·50
6	·85	·00	3·40	1,228	740	1660	307·00
Total .	4·65	·35	22·90	7,580	4485	10141	1895·00
Average	·775	·0583	3·816	1,263·3	747·5	1690	315·83

NOTE.—All broke short.

TABLE LXXII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	745	22,400	5,600
8		742	20,440	5,110
9		757	28,000	7,000
10		748	25,480	6,370
11		740	26,600	6,650
12		753	28,560	7,140
Total . .	...	4485	151,480	37,870
Average .	...	747·5	25,246	6,311

TABLE LXXIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 13.	No. 14.	No. 15.	No. 16.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
17·125	18·625	18·125	18·750	72·625	18·156	4·539

THE KRANJI, OR RED KRANJI TREE,

of which it is probable there are varieties of some other colour, is likewise found in the island of Borneo; it is a tree of straight growth and noble dimensions, and compares favourably with the Chow; it was imported in 1860–61 with the latter wood, and ultimately sent to Woolwich Dockyard to be employed for naval purposes.

The wood is red in colour, hard, heavy, exceedingly tough, and is one of the strongest with which we are acquainted, every one of the specimens, when tried transversely, taking a very heavy strain, and breaking with an unusually long fracture; the grain is close and somewhat resembles Cuba or Spanish Mahogany, but is

very plain. It would take a high polish, and, except for the almost total absence of "figure" to give it beauty, it would be valuable for the manufacture of furniture, or any ornamental purposes. The Kranji is chiefly used in Borneo for ship and house-building, but would be useful in a general way, and seems likely to prove fit for many of our requirements.

TABLE LXXIV.—RED KRANJI (BORNEO).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	·75	·05	4·50	1,531	1058
2	·60	·00	4·75	1,519	1067
3	·50	·00	3·25	1,382	1051
4	·75	·00	4·00	1,347	956
5	·65	·05	5·00	1,657	1046
6	·50	·05	2·75	1,460	998
Total . .	3·75	·15	24·25	8,896	6176
Average .	·625	·025	4·04	1,482·6	1029·3

REMARKS.—Nos. 1, 5, and 6 broke with very long fracture; 2, 3, and 4 much shorter, and scarph-like.

Only one piece of Kranji was tested for tensile strength, and that proved equal to a strain of 10,920 lbs. on the square inch. None were tried under the vertical or crushing strain.

KAPOR OR CAMPHOR (*Dryobalonops aromatica*)

is found also in the island of Borneo, and was imported in 1860–61 with the Chow, Pingow, and Kranji; it is of

straight growth and very large dimensions, yielding timber from 25 to 45 feet in length, and from 12 to 24 inches square. It has no rich scent like that of the camphor wood of India.

The wood is light red in colour, and has some resemblance to Honduras Mahogany; it is plain, close and straight in the grain, moderately hard and tough, and nearly as strong as the Pingow. The defects of this wood are, a sponginess about the early concentric layers, which, combined with the prevalence of star-shake, is very detrimental to the quality and usefulness of it; on this account it would be most suitable for such conversions as admit of its use in the greatest bulk.

Its employment being thus somewhat restricted, it will probably not be esteemed either among engineers or builders in this country.

TABLE LXXV.—KAPOR OR CAMPHOR (BORNEO).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	·75	·08	3·75	1,213	910
2	·60	·00	3·50	1,123	965
3	·75	·05	3·75	1,168	1053
4	·50	·05	4·00	1,236	977
5	·65	·10	4·10	1,238	936
6	·65	·00	3·50	1,127	895
Total . .	3·90	·28	22·60	7,105	5736
Average .	·65	·046	3·766	1,184·16	956

REMARKS.—All broke with splinters 4 to 8 inches in length.

TABLE LXXVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	965	25,760	6,440
8		977	28,560	7,140
Total . .	...	1942	54,320	13,580
Average .	...	971	27,160	6,790

TABLE LXXVII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
21·75	21·25	21·00	21·25	85·25	21·31	5·33

Borneo produces several other species of trees, including the Tanjan, Meraha, Panjan, and the Kampar. These all attain good building sizes, and, judging from the sample logs sent with the Chow, &c., to this country, I am inclined to think they would be found useful and valuable for constructive purposes.

THE MOLAVÉ TREE (*Vitex geniculata**)

is found in the Philippine Islands, and, judged by the parcel of 6 to 8 loads of selected wood imported here in 1863 or 1864, is of straight growth and moderate dimensions, although, according to Blanco, it is "very often crooked."

* Blanco's "Philippine Flora."

The wood is yellowish or straw-colour, hard, heavy, strong, close in the grain, and possesses a figure or waviness that somewhat resembles satin-wood; hence it may be found useful not only in building, but for cabinet purposes. It is said to be used extensively in the Philippines for all kinds of work.

The Molavé timber appears to be of good quality, and has the property of seasoning without much shrinkage or splitting; it also stands exposure to the weather for a long time without showing any signs of being deteriorated by it. In the Philippines it is considered to be very durable.

Judging from the appearance of the parcel referred to, it can be recommended to notice, as being fit to supplement any of the hard woods in present use for constructive purposes.

TABLE LXXVIII.—MOLAVÉ (PHILIPPINE ISLANDS).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·10	5·00	1,200	972
2	1·25	·25	5·75	1,320	987
3	1·25	·15	4·75	1,210	1080
Total . .	3·75	·50	15·50	3,730	3039
Average .	1·25	·166	5·166	1,243·3	1013

REMARKS.—Each piece broke with a long scarph-like fracture.

TABLE LXXIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
4	2 × 2 × 30	987	30,240	7,560
5		972	29,120	7,280
6		1080	34,720	8,680
7		954	20,160	5,040
8		1115	42,000	10,500
Total . .	...	5108	156,240	39,060
Average .	...	1021·6	31,248	7,812

The following woods are also found in the Philippine Islands, namely—

2. Lauan,
3. Banaba,
4. Dougon,
5. Ypil,
6. Lacolaco,
7. Acle,
8. Tindalo (two sorts),
9. Diladila,
10. Yacal,
11. Mangachapuy,
12. Karra,
13. Guigo,
14. Camayuan.
15. Malatapay,
16. Palo Maria,
17. Mapilia,
18. Mambog,
19. Bolongnita,

and some of them are considered to be of a very useful description, Nos. 2 and 7 especially so.

The Lauan timber (No. 2), after some experiments had been made on specimens 0·39371 inches square by 39·371 inches in length, with the following results, was

officially reported upon to the Spanish Government only a short time ago :—

TABLE LXXX.

Arc of flexion produced by a constant weight of 2,204 lbs. hung from the centre.	Arc at which fracture took place.	Weight applied at centre of the arc.	Distance between the supporters of the wood.
Inch.	Inches.	lbs.	Inches.
0·43	3·15	14·99	23·62 and 26·77

TABLE LXXXI.

Weight of the specimen.	Resistance.			Maximum elasticity to be allowed in construction of buildings.	Weight corresponding to this elasticity.	Strength of elasticity.	Resistance to torsion co-efficient of fracture T.	
	To pressure.		Tension of strength of cohesion.					
	With the grain of the fibre.	On the grain perpendicularly.					Absolute strength.	Applicable strength.
lbs.	lbs.	lbs.	lbs.	Inch.	lbs.	lbs.	lbs.	lbs.
·948	498·24	198·41	1,529·99	·038	152·99	158·16	168·43	16·84

REMARKS.—Weight producing fracture at the bend, 1·32 lb. T co-efficient of fracture by bending, or of maximum bend.

Father Gaspard de St. Augustine says, in his manuscript History of the Philippine Islands, that the outside planks of the old Manilla and Acapulco galleons were of Lauan wood, and that it was chosen because it does not split with shot.

THE ACLE, No. 7 (*Mimosa Acle, Juga xylocropa*),*

is without thorns or excrescences. The Indians use it for the construction of their houses, and prize it for its good quality. In working it causes sneezing. The bark is

* Blanco's "Philippine Flora."

used in washing. Its leaves are not small like the generality of Mimosa, but about 8 or 9 inches long, by 3 inches broad. This wood is supposed to be identical with the Iron-wood or Pyengadu of Burmah.

The forests* of Panay (Iloilo) and Negros abound with these excellent woods, in situations most favourable for shipment.

The following trees of British North Borneo may also be mentioned: †

Billian or Iron-wood (*Eusideroxylon Zwageri*), a very durable, hard, heavy, reddish timber, suitable for piles and ship-building, and well-known in Borneo.

Mirabow, *Afzelia palembanica* (Leguminosæ), a heavy, dark-coloured, tough, and durable furniture wood, recommended as a substitute for Mahogany.

Russock or Rassak, *Vatica Rassak* (Dipterocarpeæ), a yellowish, heavy, rough-grained and durable building wood, used for piles, &c.

Serayah,
Kruen,
Gagil,
Palawan,
Rungas,
Penagah,
Urab Mata,
Epel,
Chindana,
Majow,
Ballow,
Kumpass or Compass,
Greeting.

* One of the present Chinese steam-frigates was built wholly of Philippine Island woods; and the ribs, knees, &c., &c., were cut in the forests from templates sent from the Foo-choo-foo Arsenal.

† See reports of Indo-Colonial Exhibition.

CHAPTER XXIII.

TIMBER TREES OF AUSTRALIA.

EUCALYPTUS.

AMONG the most astonishing advances in economic Botany have been the developments of our knowledge of the timbers of the remarkable and interesting Australian Myrtles belonging to the difficult genus *Eucalyptus*. The late Mr. Laslett's opinions on these timbers would probably have been more favourable had he obtained better felled and seasoned specimens, and it seems to be the opinion of Australian experts that even the much more favourable reports of the Colonial and Indian Exhibition would have been more so had more carefully chosen pieces been experimented with. In any case it seems clear that much is yet to be done with some of these timbers, and the reader is referred to Maiden's "Australian Native Plants" for further information on their mechanical and other properties.

TEWART (*Eucalyptus gomphocephala*).

This tree is also often called the White Gum, a name of no value, however, since it is shared by many other Australian trees. Is found principally in the Swan River and King George's Sound district of Western Australia. It is a tree of straight growth and noble

dimensions, yielding timber of from 20 to 45 feet in length by from 11 to 28 inches square.

The wood is of a yellowish or straw colour, hard, heavy, tough, strong, and rigid; the texture close, and the grain so twisted and curled as to render it difficult either to cleave or work. It is a very sound wood, possessing few or no defects, with the exception of a mild form of heart and star-shake at the centre, which would necessitate a small amount of waste, if it were required to reduce the logs into thin planks or boards; but, if employed in large scantlings, it will be found a most valuable wood, especially where great strength is needed.

The Tewart shrinks very little in seasoning, and does not split while undergoing that process; it is also characteristic of this wood that it will bear exposure to all the vicissitudes of weather for a long time without being in any but the least degree affected by it. I have known it subjected to this severe test for fully ten years, and when afterwards converted, it opened out with all the freshness of newly-felled timber. Possibly no better evidence is required to show that this is a durable wood.

It is used in ship-building for beams, keelsons, stern-posts, engine-bearers, and for other works below the line of flotation, for which great strength is required, a weighty material in that position not being objectionable in a ship's construction. It is spoken of very highly as a wood for use in the engine-room, where exposed to high temperatures.

In civil architecture the Tewart is far too little known in this country, although it might be employed with advantage for many purposes. It would make good piles for piers, and supports in bridges, and be useful in the framing of dock gates, as it withstands the action of water, and is one of the strongest woods known, whether

it be tried transversely or otherwise. But it would probably be found too heavy for general use in the domestic arts.

TABLE LXXXII.—TEWART (AUSTRALIAN).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·15	4·50	1,071	1147
2	1·25	·00	4·50	972	1173
3	1·15	·20	5·00	1,032	1184
4	1·25	·15	5·00	1,116	1147
5	1·35	·05	4·85	1,017	1170
6	1·35	·10	4·65	966	1194
Total . .	7·60	·65	28·50	6,174	7015
Average .	1·27	·108	4·75	1,029	1169·16

REMARKS.—Each piece broke with moderate length of fracture, and very fibrous.

TABLE LXXXIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1147	32,580	8,820
8	2 × 2 × 30	1184	44,520	11,130
9	2 × 2 × 30	1173	46,900	11,725
10	2 × 2 × 30	1170	34,160	8,540
11	2 × 2 × 30	1147	34,720	8,610
12	2 × 2 × 30	1194	51,240	12,880
Total . .	...	7015	244,120	61,705
Average .	...	1169	40,687	10,284

TABLE LXXXIV.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	4·000	16·875	37·625	67·00
17—20	4·500	16·750	33·125	64·25
21, 22	4·625	16·500		
23, 24	4·750	17·000		
Total . .	17·875	67·125	70·75	131·25
Average .	4·469	16·781	35·375	65·625
Do. per in.	4·469	4·195	3·931	4·102

The Victorian Timber Board have also made experiments on the strength of this and other Eucalyptus timbers (see Maiden's "Useful Native Plants of Australia," p. 461).

JARRAH,* OR AUSTRALIAN MAHOGANY

(*Eucalyptus marginata*),

is also found in South-Western Australia, where it is said to be very abundant. It is of straight growth and very large dimensions, but, unfortunately, is liable to early decay in the centre. The sound trees, however, yield solid and useful timber of from 20 to 40 feet in length by 11 to 24 inches square, while those with faulty centres furnish only indifferent squares of smaller sizes, or pieces unequally sided, called flitches.

* This tree, Jarrah, must not be confounded with the Yarrah (*Eucalyptus rostrata*).

The wood is red in colour, hard, heavy, close in texture, slightly wavy in the grain, and with occasionally enough figure to give it value for ornamental purposes; it works up quite smoothly, and takes a good polish. Cabinet-makers may therefore readily employ it for furniture, but for architectural and other works where great strength is required it should be used with caution, as the experiments prove it to be somewhat brittle in character.

Some few years since a small supply of this wood was sent to Woolwich Dockyard, with the view to test its quality and fitness for employment in ship-building, but the sample did not turn out well, owing to the want of proper care in the selection of the wood in the colony. The shipping officer sent only such small squares as might have been produced from logs cut or quartered longitudinally, which left in each case one weak or shaky angle, instead of sending the full-sized compact square log representing all that the growth of the tree would give. It is just possible, however, that this was unavoidable, since it may be inferred from the nature of the conversions that the trees from which they were cut commenced to decay at the centre at or about mid-life, and they had become hollow at the root-end of the stem, long before they arrived at maturity.

This remarkable defect being characteristic of the Jarrah tree, it follows that no compact and solid square log beyond the medium size can be obtained of the full growth, and hence the conversion of the faulty trees is necessarily restricted to the dimensions of flitches cut clear of the centre.

One peculiarity was noticed in the sample referred to, some of the logs had cavities or blisters, varying from one to several inches in length in the longitudinal

direction of the woody layers, and spreading from 1 to 3 inches concentrically, which occurred, like the cup-shake, at various distances from the pith, and at intervals of a few feet along the line of the trunk of the tree. These cavities were partially filled with a hard secretion of resin or gum, which made up in some measure for the solidity, although it did not impart the strength which would compensate for the deficiency of the cohesive properties common to the annual layers.*

From what has been stated respecting the Jarrah timber received at Woolwich, it will be readily supposed that the authorities there did not look upon it with favour, or any desire to employ it for ship-building purposes. It therefore passed to some of the minor services of the yard, and it was while under conversion for these ordinary and inferior works that I took the opportunity of making the experiments which are given in detail in Tables LXXXV., LXXXVI., and LXXXVII.

It is a noticeable fact in connection with the experiments, that all the specimens tried proved deficient in strength and tenacity, by breaking off suddenly with a short fracture, under an average transverse strain of about 686 lbs. weight only, or about 171·5 lbs. to the square inch of sectional area.

Since the foregoing was prepared I have seen some correspondence between the Home and Colonial Governments on the subject of Jarrah timber, and also between the Governor of Western Australia and the leading ship-builders and ship-owners, including Lloyds' surveyor at Freemantle, who had been severally asked to report

* This peculiar defect is met with in several of the Eucalyptus species, and may occasionally be seen in the Firs and Pines.

upon the merits of the Jarrah, with a view to getting it recognised at Lloyds'.

Most of the ship-builders and ship-owners have reported very favourably, and speak of it as a good description of wood. They say that, when used with iron fastenings, neither material is in any way injured by the other, and, also, what is a little remarkable, that it bends well without steaming. In speaking of its merits, however, they nearly all do so under some reserve, such as insisting on the felling being done at a certain time of the year; getting it from some particular district, and so forth. Lloyds' agent at Freemantle, however, does not report quite so favourably of it; indeed, he differs so widely from the rest, that perhaps it would be well to quote his report *in extenso* :—

" In reply to your letter relative to the qualities of the Jarrah of this country as a ship-building timber, I consider it valuable wood for planking purposes as high as the wales, and I also consider it especially excellent wood for small craft which are not intended to be sheathed with metal, inasmuch as it resists the sea-worm better than almost any other wood, and is less liable to foul; but I do not consider it suitable timber for topsides, or deck work, where it must necessarily be much exposed to the effects of the sun, it being, in such positions, more than ordinarily subject to shrink and warp; and it is rather deficient in tenacity of fibre, so that in situations where eccentric or sudden bends occur it cannot generally be employed with advantage. It is probable you may have heard of the Honourable East India Company's pilot brig *Salween* taking in a cargo of Jarrah at Bunbury. This was supplied by Mr. W. Pearce Clifton, and the vessel was sent at my instance in order to a series of trials of the wood in the Kidder-

pore dockyard. These trials, I regret to say, were not favourable to the character of the wood, and the result was that no further supply was ordered.

"When last at Calcutta I obtained the sanction of the Government of Bengal to further tests of the wood, the greater portion of the *Salween*'s cargo being then still in store, but I am sorry to say that the result was not more favourable than before."

The clerk of works at Freemantle reporting summarily upon the opinions expressed by the ship-builders and others, says:

"The sound timber resists the attack of the 'teredo navalis' and 'white ant.' On analysis by Professor Abel, it was found to contain a pungent acid that was destructive to life. The principle, however, was not found to be present in the unsound portions. Great care is therefore necessary in preparing the wood for use by flitching the log so as to cut all the defective portions of the heart out, and using only the perfectly sound timber. Fig. 25 will show the mode of flitching, so as to retain the sound wood in any required size for all practical purposes, A B C D E F being flitches. Very much has been said about Jarrah being subject to split when exported to India or England in log. It must be borne in mind that its density renders seasoning very slow, and that the inner portions of the larger trees are in a state of decay even while the outer portions are in full vigour. A tree under these conditions, the inner portions comparatively dry, and the outer full of sap, shipped at once to a hot

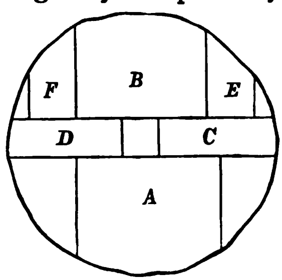


FIG. 25.

climate like that of India, or to such a variable one as that of England, very naturally ruptures from unequal shrinkage, being also exposed to very great changes of temperature. To obviate this peculiarity and apparent defect, let the Jarrah be fallen when the sap is at the lowest ebb, and flitched as previously suggested."*

I have seen it stated in some correspondence from Western Australia that a specimen of Jarrah timber has been chemically examined by Professor Frankland, with the view to ascertain whether there is any peculiar acid or other substance present in it calculated to resist the attacks of the Teredo navalis. It does not appear, however, that anything of the kind has been found which could be credited with the effect referred to. It is believed by the Professor that the singular immunity from attack which this wood enjoys is due either to the odour or taste it possesses. These, though by no means remarkable or repugnant to the human senses, are probably strongly so to the Teredo navalis.†

* The Committee of Lloyds have recently had the subject of Jarrah under their consideration, and determined to class this timber with those in line 3, Table A, of the Society's rules; thus ranking it with Cuba Sabicu, Pencil Cedar, &c., for the construction and classification of ships.

† A late Western Australian almanack says: "None of the neighbouring colonies possess timber of a similar character to the Jarrah, or endowed with equally valuable properties. If cut at the proper season, when the sap has expended itself and the tree is at rest, it will be found the most enduring of all woods. On this condition it defies decay; time, weather, water, the white ant, and the sea-worm have no effect upon it. Specimens have been exhibited of portions of wood which had been nearly thirty years partly under water and partly out. Others had been used as posts, and for the same period buried in sand, where the white ant destroys in a few weeks every other kind of wood. For this peculiar property the Jarrah is now much sought after for railway sleepers and telegraph posts in India and the colonies. It is admirably adapted for dock gates, piles, and other purposes, and for keel-pieces, keelsons, and other heavy timber in ship-building. Vessels of considerable burthen are built entirely of this wood, the peculiar properties of which render copper sheathing unnecessary, although the sea-worm is most abundant in these waters."

From the foregoing statements it will be seen that there is great diversity of opinion upon the merits of Jarrah timber, and time only will show whether if imported it will find favour with ship-builders and others in this country.*

Some three or four years since (about 1871) the Western Australia Timber Company were busily engaged in the forests preparing a large quantity of Jarrah for exportation. The company professes, I believe, to select only the best trees, and to cut them at the proper season; the deliveries should therefore be of the very best sort the country produces. I have earnestly looked for sample cargoes to arrive in the London Docks, but up to the present (1875) none of any importance have been reported.

TABLE LXXXV.—JARRAH (AUSTRALIA).
Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·85	·10	4·50	743	987	753	185·75
2	3·25	·15	4·50	638	1049	608	159·50
3	3·25	·15	5·00	661	977	677	165·25
4	3·50	·15	5·00	661	1039	636	165·25
5	3·15	·10	4·50	726	1006	722	181·50
6	3·25	·15	4·75	685	1002	684	171·25
Total .	19·25	·80	28·25	4,114	6060	4080	1028·50
Average	3·21	·133	4·71	685·66	1010	680	171·416

REMARKS.—Each piece broke short

* It may now be conceded that Jarrah is a more valuable timber than was formerly supposed, especially where durability is required, as in pile-work, sleepers, ship-building, &c. It has been extensively employed for wooden pavements with success.

TABLE LXXXVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7 8	} 2 × 2 × 30 {	987 1006	10,080 13,440	2,520 3,360
Total . .	...	1993	23,520	5,880
Average .	...	996	11,760	2,940

TABLE LXXXVII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
12·875	13·000	12·625	12·750	12·750	12·750	76·75	12·792	3·198

KARI (*Eucalyptus diversicolor*)

is found in South-Western Australia, and is said to be very abundant. It is of straight growth, and can be obtained of extraordinary size and length; no reasonable limit to its dimensions being necessary, except that of the capacity of a ship to carry it. Governor Weld, of Western Australia, says he has estimated trees of this description at 300 feet; and the learned botanist, Baron Van Mueller, of Melbourne, states that the Kari tree reaches the height of 400 feet.

The wood is red in colour, hard, heavy, strong, tough, and slightly wavy or curled in the grain, but it has no figure to recommend it for cabinet purposes. Six logs of this timber, viz., two of 12″ × 12″ × 28′, one of 12″ × 12″ × 34′, two of 24″ × 24″ × 24′, and one of 24″ × 24″ × 32′, were recently shipped at Freemantle by the Western Australian Government for delivery at one of the royal dockyards in England, for experimental trial in the navy, the colonists being of opinion that it will ere long be in great request for ship-building and other architectural works. Unfortunately, however, all these logs had the defect of star-shake, which rendered them unfit for almost any purpose except where they could be employed in very large scantlings.

It was also noticed that the Kari had the peculiar blistery appearance of the annual layers which has been mentioned as common to the Jarrah, consequently this wood is not considered to be suitable for any work requiring nicety of finish, although no doubt it would be admirably suitable for piles for jetties, bridges, &c., and generally for heavy structures where large scantlings and great strength is required. It will not last between wind and earth, though, as far as is yet known, it resists the action of water. It is, moreover, more difficult to work than Jarrah, and does not finish well in the moulding and planing machine.

It is much to be regretted that a tree so noble in its dimensions should prove so disappointing in its character; but, like the Jarrah, to which it has some resemblance, it is not, I think, likely to be in request for architectural works in this country.

TABLE LXXXVIII.—KARI (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	·75	·00	5·00	820	957
2	1·25	·00	6·25	725	885
3	1·35	·10	4·60	955	1023
4	·75	·05	7·50	840	987
5	1·00	·05	6·50	920	1013
6	1·00	·05	6·50	915	1023
Total . .	6·10	·25	36·35	5,175	5888
Average .	1·01	·04	6·06	862·5	981·33

REMARKS.—Each piece broke with scarph-like fracture, 8 to 10 inches in length.

TABLE LXXXIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	...	31,080	7,770
8		...	30,800	7,700
9		...	31,360	7,840
10		...	31,360	7,840
11		...	22,120	5,530
12		...	22,960	5,740
Total . .	...	...	169,680	42,420
Average .	...	981·	28,280	7,070

TABLE XC.

Vertical or Crushing Strain on cubes of 6 inches.

No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	
175	195	370	185	5·14

IRON-BARK (*Eucalyptus resinifera*)*

is found very widely spread over a large part of Australia, and is considered to be abundant, especially in South Queensland; but it is rarer than formerly. It is a lofty and erect tree of moderate circumference, and yields timber of from 20 to 40 feet in length, by from 11 to 16 or 18 inches square. It is believed to have been named as above by some of the earliest Australian settlers, on account of the extreme hardness of its bark; but it might with equal reason have been called iron-wood.

The wood is of a deep red colour, very hard, heavy, strong, extremely rigid, and difficult to work. It has a plain straight grain, and the pores, which are very minute, are filled with a hard, white, brittle secretion. The tree is generally sound, but liable to the defect of both heart and star-shake, and on this account it is not usually very solid about the centre, consequently the timber cannot be employed with advantage except in stout planks or large scantlings.

It is used extensively in ship-building and engineering works in Australia, and in this country it is employed in the mercantile navy for beams, keelsons, and in many

* This species is now known as *E. siderophloia*, and must not be confounded with the *E. resinifera* of New South Wales and Queensland (see Maiden—"Australian Native Plants," p. 509).

ways in the construction of ships, especially below the line of flotation, where a heavy material is not considered objectionable. For civil architecture, the ornamental and the domestic arts, it is not, however, likely to be in much request, its extreme hardness and great weight precluding it from general use.

TABLE XCI.—IRON-BARK (AUSTRALIA).
Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	·85	·0	3·75	1,460	1163
2	1·00	·0	3·50	1,370	1146
3	·90	·0	4·00	1,400	1142
4	1·00	·0	4·00	1,400	1116
Total . .	3·75	·0	15·25	5,630	4567
Average .	·94	·0	3·812	1,407·5	1142

REMARKS.—No. 1, wiry fracture, 16 inches in length; No. 2, wiry fracture, 12 inches in length; No. 3, wiry fracture, 10 inches in length; No. 4, broke short to one-third depth, then splintery fracture, 10 inches in length.

TABLE XCII.
Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
5	2 × 2 × 30	1142	34,160	8,540
6	2 × 2 × 30	1146	26,880	6,720
7	2 × 2 × 30	1163	39,480	9,870
Total . .	...	3451	100,520	25,130
Average .	...	1150	33,507	8,377

TABLE XCIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 8.	No. 9.	No. 10.	No. 11.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
18·500	17·625	18·500	19·000	73·625	18·406	4·601

BLUE GUM (*Eucalyptus Globulus*)*

is found abundantly spread over a great part of Australia and Van Diemen's Land. It is a tree of straight

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* In reference to the *Eucalyptus Globulus*, the following appeared in the *Homeward Mail* in 1873:—

"A DISEASE-DESTROYING TREE.—M. Gimbert, who has been long engaged in collecting evidence concerning the Australian tree, *Eucalyptus Globulus*, the growth of which is surprisingly rapid, attaining, besides, gigantic dimensions, has addressed an interesting communication to the Academy of Sciences. This plant, it now appears, possesses an extraordinary power of destroying miasmatic influence in fever-stricken districts. It has the singular property of absorbing ten times its weight of water from the soil, and of emitting antiseptic camphorous effluvia. When sown in marshy ground it will dry it up in a very short time. The English were the first to try it at the Cape, and within two or three years they completely changed the climatic condition of the unhealthy parts of the colony. A few years later its plantation was undertaken on a large scale in various parts of Algeria. At Pardock, twenty miles from Algiers, a farm, situated on the banks of the Hamyze, was noted for its extremely pestilential air. In the spring of 1867 about 1,300 of the *Eucalyptus* were planted there. In July of the same year, at the time when the fever season used to set in, not a single case occurred, yet the trees were not more than nine feet high. Since then complete immunity from fever has been maintained. In the neighbourhood of Constantine the farm of Ben Machydlin was equally in bad repute. It was covered with marshes both in winter and summer. In five years the whole ground was dried up by 14,000 of these trees, and farmers and children enjoy excellent health. At the factory of the Gue de Constantine, in three years a plantation of *Eucalyptus* has transformed twelve acres of marshy soil into a magnificent park, whence fever has completely disappeared. In the island of Cuba this and all other paludal diseases are fast disappearing from all the unhealthy districts where this tree has been introduced. A station-house at one of the ends of the railway viaduct

growth, and attains a height of 200 to 300 feet, with a diameter of from 6 to 25 feet. Like the Jarrah, it is characteristic of the larger trees, that, while they appear to be healthy and vigorous, and continue to increase in height and bulk, the centre wastes away near the root, and, when felled, they are often found hollow for some considerable distance up from the butt. The dimensions of the serviceable logs which the tree yields will, therefore, depend very much upon its soundness; but, unquestionably, very large scantlings can be procured from it if required.

The wood is of a pale straw colour, hard, heavy, moderately strong, tough, and with the grain twisted or curled. In seasoning deep shakes occur from the surface, and it shrinks and warps considerably.

I remember to have seen in one of the royal dockyards some extremely long and broad planks, or thick-stuff, of this description of timber, which had been apparently flitched from some of the hollow trees before referred to. These, after being kept to season for a while, warped and split to such an excessive degree that it was impossible to use them for any planking purpose whatever. In consequence of this defect it was found necessary to reduce the planks to very short lengths, in order to utilise them at all, and so they passed to quite inferior services.

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in the Department of the Var was so pestilential that the officials could not be kept there longer than a year. Forty of these trees were planted, and it is now as healthy as any other place on the line. We have no information as to whether this beneficent tree will grow in other but hot climates. We hope that experiments will be made to determine this point. It would be a good thing to introduce it on the West Coast of Africa."

Similar accounts are published from other parts of the world, but, without denying the substratum of truth in the statements, it seems clear that many of them are exaggerated.

A specimen log of Blue Gum $31' \times 24'' \times 28''$ was forwarded with other woods to the London Exhibition of 1862 by the Tasmanian Commissioners; and this, at the close of the Exhibition, was transferred to Woolwich Dockyard for trial experimentally in ship-building. It came in, however, too late, and just when wood was giving place to iron in this branch of architecture, so that no favourable opportunity ever offered for its employment.

This log, although of very large dimensions, had been cut clear of the centre, and very probably had formed part of one of the hollow trees before alluded to, consequently the tree to which it belonged must have been at the least 6 to 7 feet in diameter.

A plank 6 inches thick was cut from it, which quickly warped or twisted 2 inches, and ultimately went to 3½ inches, and stood at that in 1870. Upon examination then, it was found to be full of deep, fine shakes, but otherwise it was not much changed, and there were no signs whatever of decay, although it had been for a long time exposed to the weather. It seems, therefore, likely to be a durable wood.

In the Australian colonies the Blue Gum is largely employed in ship-building for keels, keelsons, beams, and planking; and in civil architecture for any service where long, straight, and heavy timber is required. It is also largely used upon the farms for fences, &c.

TABLE XCIV.—BLUE GUM (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·15	4·50	767	1079
2	1·75	·20	3·75	602	997
3	1·35	·10	5·75	710	1037
4	1·00	·00	3·75	767	1108
5	1·25	·15	3·50	684	1026
6	1·00	·00	4·00	741	924
Total . .	7·60	6·0	25·25	4,271	6171
Average .	1·26	·10	4·21	712	1029

REMARKS.—Each piece broke with a short fracture.

TABLE XCV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	997	14,560	3,640
8	2 × 2 × 30	1079	26,600	6,650
9	2 × 2 × 30	1037	24,360	6,090
10	2 × 2 × 30	1108	26,600	6,650
11	2 × 2 × 30	1026	28,840	7,210
Total . .	...	5247	120,960	30,240
Average .	...	1049	24,192	6,048

TABLE XCVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 12.	No. 13.	No. 14.	No. 15.	No. 16.	No. 17.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
12·875	13·000	12·750	11·125	10·500	13·625	73·875	12·312	3·078

STRINGY-BARK* (*E. obliqua*)

is of straight growth, and takes its name from the strip-like character of its bark. It is very abundant in Australia and Van Diemen's Land, and flourishes well in any situation, provided the soil be dry. It attains a height of from 100 to 230 feet, with a diameter of from 3 to 15 feet.

The wood is of a brown colour, hard, heavy, strong, close, and straight in the grain. It works up well, and is much employed in the colonies in ship-building, for planking, beams, keels, and keelsons, and in civil architecture for joists, flooring, &c. Upon the farms it is used for fences and agricultural implements; it is also employed for furniture and for all ordinary purposes, and is probably the most generally used of all Eucalypts.

The Stringy-bark is liable to the peculiar defect noticed in the Jarrah, and described at p. 232. In a specimen of this wood obtained in 1842 from "Cook's tree" in a forest bordering on Adventure Bay, Van Diemen's Land, there are several imperfect annual layers, which are partially filled with a reddish resinous

* This name is given in Australia to at least a dozen different species of *Eucalyptus*.

secretion. It is believed that this specimen was cut from the identical Stringy-bark tree which Captain Cook marked to denote his visit to that place. When I saw it, the tree was partially destroyed, and it is probable that Cook's marks had long before disappeared. It bore on the north side the letters—

LE
GEO GR
ac
GA

and on the south side—

LAN 1802
LAFR=GA
AP:—L
DE....

The Tewart, Jarrah, Kari, Iron-bark, Blue-gum, and Stringy-bark trees, are among the noblest of the vegetable products of Australia and Van Diemen's Land; but there are many others of nearly equal value.

The following table contains a list of these woods, with the particulars of their growth, the soils favourable to them, and the several uses for which they are most suitable; observing that the specimens were collected, and the information respecting them given, by an intelligent sawyer who had been many years employed in the colony.*

* Unfortunately the value of this list is diminished owing to the vague popular names only being given.

TABLE XCVII.

Description.	Hgt.	Dia.	Where found.	Uses.
	Ft.	In.		
White Gum . .	150	25	Hard, dry ground	Floors, futtocks, treenails.
Brown do. . .	30	24	Do. do.	Ship - building (harder than the other Gums).
Curly do. . .	100	20	Do. do.	Floors, futtocks, ship-building.
Red do. . .	40	18	Low, marshy.	Fencing.
Swamp do. . .	200	30	Do. do.	Shingles, laths, fencing.
White, Stringy Bark . . .	...		In all situations.	Roofs, joists, flooring-boards.
Brown Peppermint . . .	60	24	Dry.	Flooring-boards, charcoal.
White do. . .	50	24	Dry, hard.	Shingles, laths, fencing.
Scented Myrtle .	15	6	Low, marshy.	Seldom used.
Red do. .	40	12	Swampy.	Same purposes as Pine.
White do. .	20	9	Low, marshy.	House-carpenters' use.
Yellow do. .	20	9	Do. do.	Do. do.
Brown do. .	20	30	Do. do.	Do. and joiners' planes.
Black Wattle .	15	8	Hard, dry.	Bark used for tanning.
Prickly do. . .	20	6	Low, marshy.	Seldom used.
Silver do. . .	40	12-30	Do. do.	Boat oars; bark for tanning
He Oak. . . .	18	12	Hard, dry.	Firewood.
She Oak, or Beefwood .	18	12	Hard, dry, hilly.	Furniture, firewood.
Boxwood . . .	12	9	Do. do.	Block sheaves, caulking-mallets.
Blackwood. . .	15	12	Creek sides.	Naves for wheels, turning.
Lightwood. . .	50	24	Low, marshy.	Staves, cabinet - makers' work.
Dogwood . . .	20	9	Fine, dry.	Not much used.
Pinkwood . . .	15	6	Low, marshy.	Turners & cabinet-makers.
Stinkwood . . .	20	8	Fine, dry.	Cabinet-makers' work.
Forest Lightwood	15	12	Hard, dry.	Naves for wheels, turning.
Black Willow . .	short	6	Sides of creeks.	Basket-makers.
Brown do. . .	small	small	Do. do.	Not used.
White do. . .	15	8	Hard, dry.	Seldom used.
Honeysuckle . .	12	12	Dry.	Floors and knees of small vessels.
Laurel	15	9	Low, marshy.	
Pencil Cedar . .	50	24	Do. do.	Staves (not much used).
Celery - topped Pine . . .	20	20	Do. do.	Doors, sashes, &c.
Sassafras . . .	40	14	Do. do.	Sashes and door-frames.
Cabbage Tree .	15	10	Hard, dry, rocky.	Seldom used.
Plum do. .	12	10	Low, marshy.	Gun-stocks.
Emu do. .	small	small	Do. do.	Turners' work.
Cherry do. .	30	9	Hard, dry.	Tool-handles.
Swamp Tea Tree.	12	6	Low, marshy.	Useless.
Tea Tree . . .	30	9	Do. do.	Turners, Agricultural Implements.
Musk do. . . .	12	small	Do. do.	Do. do.

The following Eucalypts ought also to be noted :—

E. amygdalina, the Giant Gum, also known as Peppermint Tree, and by a variety of other names, is especially remarkable as furnishing the tallest trees in the world, one having measured 471 feet, and several reaching 400 to 420 feet in height. It is very useful for straight work in carpentry, as it does not twist on drying; it is hence peculiarly valuable for splitting—rails, &c. The wood is light and buff-coloured, and is said to be durable.

E. botryoides, one of the many "Blue Gums," is often termed Bastard Mahogany, and yields a hard, tough, durable, and valuable ship-building and waggon timber, which does not split easily.

E. capitella, "White Stringy-bark," is a useful splitting timber for fence and building work; *E. corymbosa*, the "Blood Gum," has similar uses.

E. corynocalyx, "Sugar Gum" of South Australia, is said to be least likely to warp when exposed of all the Australian timbers. It is yellowish, and particularly strong, hard, and heavy, and one of the most durable and resistant of woods. Of course it is correspondingly difficult to extract and work, but its properties as timber for sleepers, piles, &c., are spoken of so highly that it seems to deserve more attention.

E. crebra, an "Iron-bark" of Queensland and New South Wales, is also described as an excellent, hard, fibrous, and durable brown timber, but very hard to work. Similar characters are ascribed to *E. goniocalyx*, much esteemed by wheelwrights.

E. Gunnii, the Cider Gum of Tasmania, yields a sweet sap often converted into a drink, and the timber is more valued for charcoal than for constructive purposes.

E. hemiphloia, the "Box" of New South Wales, &c., yields a Box-like timber famous for its hardness and durability, and much used for sleepers, bridges, and railway-work, ship and coach-making, cogs, &c.

E. leucoxylon, the common "Iron-bark," is also said to be a very superior timber for the above purposes, but there has been much confusion regarding its names.

E. maculata, the "Spotted Gum" of New South Wales, is in great demand for ship and bridge-building, paving, and other durable work.

E. melliodora, the "Yellow Box," has a hard, tough, durable and close-grained wood, used in engraving, but hardly suitable for large work.

E. paniculata, "Blood-wood," is reputed durable; but *E. pauciflora* is soft and short-grained, whereas *E. pilularis*, the "Black-butt," is said to be an excellent carpenters' wood, &c. *E. piperita*, *E. polyanthema*, *E. punctata*, and *E. robusta* are also worthy of note.

E. rostrata, the common Red Gum, is highly valued for its durability in damp ground, as in ship and bridge-building, sleepers, &c.; but it is so hard when dry that difficulties in working it limit its applications to furniture, &c. It is said to rival Jarrah in value as a timber, and has been much used in construction.

E. saligna, with various names, is regarded as good for fences, rails, and spars, &c., and is widely used.

E. Sieberiana, the Cabbage Gum, is very soft, but curiously durable under ground according to some, while others deny this.

E. Stuartiana, the "Turpentine Tree," yields good timber for ships' planks, &c. *E. tereticornis* has a Cedar-coloured wood good for fencing, &c., while *E. tesselaris*

is described as good for flooring, &c. *E. viminalis*, the White Gum of Tasmania, is not very durable, but useful in rough building work and for split-stuff, and several other species are used for minor purposes in the colony.

AUSTRALIAN "OAKS."

There are no true Oaks in Australia, but the name has been transferred by the colonists to the timber of various species of *Casuarina*, a totally different family with no relationship to the genus *Quercus*. These trees are very remarkable in many respects, and it is the merest superficial resemblance between the timbers—chiefly turning on the broad medullary rays, and partly the colour—that has suggested the name "Oak" for them. The usual colour of *Casuarina* wood is that of deep red Mahogany, with dark veinings and markings, and the grain has some resemblance to that of the Evergreen Oaks of Asia. There are various species in Australia, and one or two have now been planted elsewhere. The following are the most important, some being especially good fuel:—

Casuarina equisetifolia, the Swamp Oak or Beefwood, with a coarse-grained but beautifully-marked structure, and employed for fencing, gates, shingles, &c., in work where lightness and toughness are required. It is described as very durable.

C. stricta, the Shingle Oak, regarded as a fine furniture wood, and with very handsome mottling and capable of being turned, polished, and well worked.

Several other species are known, but used chiefly as fuel, under the names of "He Oak," "She Oak," "River Oak," &c.

OTHER AUSTRALIAN TIMBERS.

The following Australian timbers may also be noted, with the remark that much observation and experiment are still needed before our information concerning them is complete :—

Acacia Cunninghami, a close-grained and useful cabinet wood, not unlike Red Cedar, but heavier; *A. decurrens*, much used for staves; *A. excelsa*, a beautiful cabinet wood, with the peculiar violet odour found in several of these Acacias; *A. melanoxylon*, the "Blackwood," one of the most valuable timbers of Australia, and employed for all kinds of construction, carpentry, and ornamental work, and well reported upon at the Indian and Colonial Exhibition; and *A. salicina*, used for furniture. Several others of the many Australian Acacias, or "Wattles," are also used in carpentry, cabinet work, and turning, and would probably repay further inquiry into their value for these purposes. *Achras australis* and some other species of sapotacæ also seem worthy of trial, and the same is probable of some of the Australian *Albizzias*.

Cedrela Toona, the Toon of India, is well known and valued in New South Wales and Queensland under the name of Cedar, or "Red Cedar." See p. 209.

Ceratopetalum apetalum yields the "Light-wood" or "Coach-wood" of New South Wales, a tough timber used especially in carriage-making.

Daviesia arborea, the "Queen-wood," is highly spoken of as a timber "destined to take a prominent position with cabinet-makers."

Dysoxylon Fraserianum, often termed Rose-wood and Pencil Cedar, is a Mahogany-like, fragrant wood,

very valuable for indoor work, cabinet-making, ship-building, &c.

Eugenia myrtifolia, *E. Jambolana* and some other species are useful woods, chiefly for small work.

Exocarpus cupressiformis, the "Native Cherry," is not a Cherry at all, but an ally of the Sandal-wood of India, and is a close-grained and handsome wood, quite common, and used for all kinds of turnery, &c.

Fagus Cunninghami, known as the Myrtle, or Evergreen Beech,* is a true Beech found in Tasmania and Victoria, and is a hard, richly-coloured furniture and carpenters' wood, much prized for all kinds of joinery.

Ficus macrophylla, *F. scabra* and other Figs yield timber of little value in Australia.

Flindersia australis, sometimes called Ash,† is a hard, close, and very durable timber, well known, but so difficult to saw that it is neglected. Several other species of *Flindersia* are used also.

Fusanus spicatus is the Sandal-wood of Australia, but not of India, though they belong to the same natural family. It has been for some time a valuable export

* Beech is another wood on the road to being spoilt by our Australian colonists. Numerous trees go by this name in Australia—*Cryptocarya glaucesceus*, *Flindersia australis*, *Gmelina Leichardtii*, *Monotoca elliptica*, *Trochocarpa laurina*, *Elæcarpus Kirtoni*, and several others, none of which have any real resemblance to the true Beeches.

† The word "Ash" is applied to various very different trees in different parts of the world. The Cape Ash is *Ekebergia capensis*; the Rhamnaceous *Alphitonea excelsa* is called the Red Ash in Australia, and various other trees go by the name of Ash in the colony. Our common Rowan (*Pyrus aucuparia*) is often called the Mountain Ash, though it is no more a true Ash than the very different tree (*Elæocarpus longifolia*) called by the same name in New South Wales. The Australian *Flindersia australis* is also dubbed Ash in Queensland, but as it also goes by the name of Beech, &c., some idea can be obtained of the flagrant looseness of application of these terms. *Cupania semiglauca* and *Litsæa dealbata* are both called Black Ash in Australia, though the true Black Ash is *Fraxinus sambucifolia* of North America.

timber in West Australia, chiefly to China, but it is becoming scarce. *F. acuminatus* is also a valuable cabinet wood, and is interesting as being one of the hard woods used by Australian aborigines to obtain fire by friction.

Gmelina Leichhardtii, the White Beech, is allied to Teak, and is a useful, strong, easily-worked timber, prized for decks and floorings.

Grevillea robusta, called Silky Oak, but in no way allied either to the true Oaks or the Australian "Oaks," is one of the Proteacæ, now becoming scarcer owing to its extensive employment for the staves of tallow-casks, &c. It is also much used for interior work in houses. *G. striata* is the Beef-wood, so called from the resemblance of the worked timber to raw beef, much valued for cabinet work.

Hedycarya angustifolia, the native "Mulberry," is not a mulberry at all. The wood is a cabinet wood, and preferred by the natives for obtaining fire by friction.

Heritiera littoralis is the Sundi of India, and called Red Mangrove in Queensland.

Melaleuca leucadendron, the White Tea Tree, is an extremely pretty wood, with ripple markings, and extremely durable in the ground. *M. ericifolia*, the Swamp Tree Tree, and *M. styphelioides*, the Prickly Tea Tree, are also durable. These Tea Trees have nothing to do with Tea; they are Myrtles.

Melia Azedarach, the Persian Lilac, or Bastard Cedar of India, is known in Australia as the White Cedar.

Notelæa ligustrina, the Iron-wood of Tasmania, is so hard as to rival Lignum Vitæ, and is used for blocks, &c., in the same way.

Olearia argophylla, Musk-wood, is a common, fragrant, and beautifully mottled turnery wood.

Owenia venosa, the Sour Plum, is allied to the Mahogany, and is said to be a very strong and durable, ornamental, yellow and black timber.

Panax Murrayi, the Pencil-wood of New South Wales, is said to be the lightest wood in Victoria, and cuts splendidly for lining boards. It must not be confounded with the Pencil Cedars or other Cedars of commerce.

Stenocarpus salignus, often called Silky Oak (but again different from any other so-called "Oaks"), is a valuable, but now rather scarce, furniture and coopers' wood.

Syncarpia laurifolia, Turpentine Tree of New South Wales, is valuable for piles, ship-building, &c., owing to its resistant properties, due to resinous contents.

Synoum glandulosum, Dog-wood, is a Cedar-like, scented, red wood for inside work.

Tristania conferta, the White Box of New South Wales, is used in ship-building; *T. suaveolens*, Bastard Peppermint, for carriage work, &c., and others of these Myrtles for various purposes.

These are by no means all the useful timbers of Australia, and the reader is referred to Maiden's "Useful Native Plants of Australia" for further information.

CHAPTER XXIV.

THE TIMBER TREES OF WEST INDIA AND CENTRAL AMERICA.

AMONG the rich variety of Timber trees met with in Central and South America, and the Islands known generally as the West Indies, a considerable number never reach our markets. For our purpose it will suffice that we note the following valuable species.

MAHOGANY.

The term Mahogany is applied to very different timbers in various parts of the world. True Mahogany is yielded by *Swietenia*, one of the Cedrelaceæ, and is also termed Bay-wood by the cabinet-makers. The Toon of India (*Cedrela Toona*) is also often called Indian Mahogany, though, perhaps, it is more commonly known under the equally inaccurate name of Cedar (see p. 209). African Mahogany is a totally different plant (*Khaya Senegalensis*), and the same is true of the following: Bastard Mahogany (*Ratonia apetala*), East Indian Mahogany (*Soymida febrifuga*), Mountain Mahogany (*Betula lenta*), Madeira Mahogany (*Persea indica*), while various species of *Eucalyptus* (*E. marginata*,

E. botryoides, *E. resinifera*, *E. pilularis*, *E. robusta*, &c.) are known as Mahogany in Australia.

MAHOGANY, SPANISH (*Swietenia Mahogani*),

is the produce of a large Cedrelaceous tree found in Central America, Mexico, and the island of Cuba, and others of the West Indies, and is indiscriminately called the Spanish or Cuba Mahogany. It is a tree of perfectly straight growth, and yields timber for the market of from 18 to 35 feet in length, by from 11 to 24 inches, dressed quite square, and generally with two or three stops or joggles, with the view to preserve as much timber as possible in the stem of the tree. (*Vide* Fig. 26).

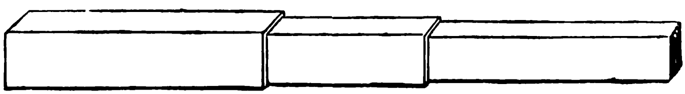

FIG. 26.

The wood is of a reddish-brown colour, hard, heavy, strong, close and straight in the grain, with occasionally a wavy or figured appearance; it is also very solid, especially about the centre, or pith, the heart-shake in this variety of the Swietenia being quite insignificant; the cup and star-shakes are also rare, and there is little sap-wood; so that it need not give us any anxiety in dealing with it, whatever may be the nature of the conversion required. It is susceptible of a very high polish, and with the wave or figure well marked, it possesses great beauty; indeed, if worked up for furniture, or used for any ornamental purposes whatever, we cannot fail to

admire it. The figured logs, therefore, possess a considerably enhanced value over those of a plainer description, and high, even fabulous prices are often realised for them.

Cuba or Spanish Mahogany is durable, and is employed for a variety of purposes. It has been very advantageously used in the building of ships of war in place of Oak for beams, planking, stanchions, &c.; its strength and rigidity rendering it admirably fitted for these, while, being of moderate specific gravity, it was safe to use it either above, at, or below the line of flotation; but in civil architecture it is not much used, on account of the high price it obtains over other woods.

TABLE XCVIII.—MAHOGANY (CUBA, OR SPANISH).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·50	·00	3·50	767	720
2	1·50	·00	3·50	883	817
3	1·25	·05	3·50	817	789
4	·85	·00	3·85	956	752
5	1·15	·05	3·35	883	765
6	1·00	·05	3·00	831	771
Total . .	7·25	·15	20·70	5,137	4614
Average .	1·208	·025	3·45	856·16	769

REMARKS.—Nos. 1 and 4 broke with moderate length of fracture, and splintery; 3, 5, and 6—each broke very short.

TABLE XCIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 x 2 x 30	752	19,040	4,760
8		765	19,824	4,956
9		817	15,120	3,780
10		720	11,200	2,800
11		771	10,640	2,660
Total . .	...	3825	75,824	18,956
Average .	...	765	15,165	3,791

TABLE C.

Vertical Experiments on cubes of—

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	2·500	12·750	27·250	38·750
16—19	2·750	11·875	27·375	39·150
20—23	2·875	13·625	26·800	38·625
24—27	2·875	13·750	27·425	39·100
Total . .	11·000	52·000	108·85	155·625
Average .	2·750	13·000	27·212	38·906
Do. per in.	2·75	3·25	3·024	2·431

NOS. 28 TO 36.—Four more pieces—each 2 x 2 x 2 inches—tried under the vertical pressure, took, on the average, 13·937 tons, or 3·484 tons to the square inch, to crush them. Two pieces, each 3 x 3—the one 11 inches, the other 16 inches in length—bore 27· tons and 25·5 tons. Two other pieces, each 4 x 4 inches—the one being 8 inches, the other 13 inches in length—bore respectively 47·75 tons and 38·5 tons; and one piece—12 x 12 x 15 inches in length—bore 481 tons, or 3·34 tons per square inch of base.

ST. DOMINGO MAHOGANY

is very similar in quality, but of much smaller dimensions than that of Cuba, and only a few logs exceeding 8 to 10 feet in length, by 12 to 13 inches in the mean thickness of their scantlings, are imported into the markets of this country, although they are occasionally seen in well-squared logs, measuring $15'' \times 15'' \times 25'$.

The wood is of a deep red colour, hard, almost horny, heavy, strong, and very solid at the centre; it has a good figured grain, and near to the top of the stem, where it branches off, there is generally a rich and pretty feather or curl in it, which is much prized by cabinet-makers, especially when it is of sufficient length for table-tops, or the fronts of drawers. It shrinks very little, and rarely splits externally in seasoning.

The average measurement of the logs imported is only about 100 superficial feet of 1 inch; while the pieces brought over as curls are seldom more than about 12 superficial feet. Owing to the very small dimensions of this Mahogany tree, there is scarcely any that is available for architectural works, and the supply which comes to us goes solely to meet the demand for cabinet and ornamental purposes.

NASSAU MAHOGANY.

This is even more dwarfish in character than the Mahogany of St. Domingo, and the logs imported have rarely exceeded 5 or even 3 feet in length, dressed into neat squares of 6 to 12 inches, the latter size being, however, rare. The measured contents of these logs average only about 8 to 9 superficial feet of 1 inch thick.

The wood is deep red in colour, hard, heavy, equally horny with the St. Domingo Mahogany, very firm and solid at the centre, fine and close in texture, and is generally veined or figured, or in curls; hence it is very suitable for cabinet work in a small way, and for turnery.

HONDURAS MAHOGANY.

This tree, which was formerly found in great abundance in the forests of Central America, near to Belize, was first imported into England about 1724 or 1725; the supply is, however, gradually failing; but until quite recently it has been brought in sufficient quantities, annually, to meet the requirements of this country; it is therefore well known to commerce as a most valuable wood for furniture purposes.

In contrast with the two varieties last mentioned, these Mahogany trees of Honduras are very tall, and rise 40 to 50 feet to the branches, with a circumference of 6 to 9 feet; they are generally straight, but are not unfrequently of an irregular or crooked growth; they yield very fine logs of 25 to 40 feet in length, by 12 to 24 inches square, and some are occasionally met with of much larger dimensions; but even this does not show, fully, the length of useful wood in this noble tree, since we learn from those engaged in the trade that each tree is cut several feet up from the ground, and that in this way is involved a very unnecessary amount of waste of a most valuable article.

The wood is red in colour, moderately hard, strong, tough, flexible and elastic while fresh, but becomes somewhat brittle when thoroughly dry; it has a smooth, silky grain, works up well, and does not shrink or warp much in seasoning; it is liable, however, to split into

deep shakes, externally, if this process is carried on too rapidly. The quality of the wood varies very much, according to the situation in which it is grown; that which is produced on a firm soil and in exposed places, and notably that grown in the northern district, being by far the best, while the timber produced on the low moist grounds is generally soft, spongy, and inferior. For the most part, however, it is of a very plain character, with uniformity of colour, although occasionally logs are found with a waviness or curl in the grain, approaching to figure; and these, when worked up and polished, present an appearance of great beauty; such logs generally realise, as in the case of Cuba Mahogany, a much higher price than logs of the ordinary description, which fetch at present market prices (1875) about 4½d. to 6d. per foot superficial of 1 inch. About two-thirds only of the actual cubic contents, calliper measure, are, however, brought to sale account; the remainder or difference being allowed for the waste of saw kerfs, shakes, defects, centres, &c., in the conversion of the log into board, &c.*

The economical uses of this wood are very numerous, and it is much sought after by shipwrights, carpenters, cabinet-makers, turners, and others, who employ it for a great variety of purposes. It has been largely used in ship-building for beams, planking, and in many other ways as a substitute for Oak, and found to answer exceedingly well. It is also used extensively for cabin-fitments; and in its application to the arts there is scarcely any limit to its usefulness.

The Honduras and other descriptions of Mahogany have only about ¾ to 1 inch of alburnum or sap-wood

* This mode of measurement applies equally to all the other descriptions of Mahogany, and to Cedar.

on them, and being remarkably free from defect, the loss in conversion is comparatively small.

TABLE CI.—MAHOGANY (HONDURAS).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	2·00	·10	4·50	811	644
2	1·75	·00	3·75	821	684
3	2·25	·10	3·75	750	650
4	2·00	·05	3·55	756	662
5	1·65	·10	4·15	823	650
6	1·85	·15	4·65	851	666
Total . .	11·50	·50	24·35	4,812	3956
Average .	1·916	·083	4·058	802	659·3

REMARKS.—Each piece broke with moderate length of fracture, and splintery.

TABLE CII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	662	10,920	2,730
8		650	12,040	3,010
9		644	9,940	2,485
10		666	14,280	3,570
11		684	12,740	3,185
12		650	12,040	3,010
Total . .	...	3956	71,960	17,990
Average .	...	659	11,993	2,998

TABLE CIII.

Vertical or Crushing Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	2·675	11·00	27·75	45·000
17—20	3·000	11·00	27·00	45·500
21—24	2·675	11·25	26·875	44·875
25—28	2·875	10·75	27·875	45·125
Total . .	11·225	44·00	109·500	180·500
Average .	2·806	11·00	27·375	45·125
Do. per in.	2·806	2·75	3·042	2·820

Nos. 29 and 30.

		Crushed with the weight of	
One piece,	9″·5 × 9″·5 × 15″,	307 tons	= 3·493 tons per square inch.
,,	9″·5 × 9″·5 × 18″,	336·8 ,,	= 3·833 ,, ,,

MEXICAN MAHOGANY

is the produce of Mexico, in Central America, where it is very abundant. It is of straight growth and outvies every other description of Mahogany in its noble dimensions. It yields the timber of commerce in squares of 15 to 36 inches, by 18 to 30 feet in length. These are, however, only the ordinary lengths brought to market, the stems being generally cut into short pieces for the convenience of getting them down the hatchways of the ships, which have frequently to load in a roadstead, where it would be unsafe to open a raft-port.

Some of the trees from the district of Minatitlan must be very large, since it is no unusual thing to meet

with well-squared pieces of this timber, measuring 40 to 48 inches on the side, with every appearance of having been cut from tall trees. Hence we infer that in their growth they must exceed the height of those grown in Honduras.

The wood is red in colour, moderately hard, less strong, and with the centre more soft, spongy, and shaky than either of the varieties before referred to. Exception may, however, be taken in favour of Tabasco; the districts of Frontera, Chiltepec, Santa Ana, and Tonala, each yielding some very excellent timber.* The grain of the Minatitlan is generally very plain, but that cut in the province of Tabasco has generally some rowiness or figure to recommend it for special purposes. It is easy to work, takes a good polish, splits very little, and stands well after it is seasoned. It is tough and elastic while quite fresh, but brittle when thoroughly dry, breaking off short if subjected to a heavy strain.

The chief defect in Mexican Mahogany is the prevalence of star-shake, and this, combined with the spongy character of the early layers, or centres, of many of the trees, frequently spreading, as they do, over about one-sixth of their diameter, detracts very much from their usefulness; but, as this can all be seen by examining the ends, the converter will naturally select and appropriate the logs to the work he may have in hand, and thus avoid any serious loss.

The Mexican Mahogany is generally too large and heavy in growth to be converted profitably to ship scantlings, but is in other respects a very good substitute for Honduras for all kinds of joiners' and cabinet work,

* Mexican is sold in the London market at about the same price as Honduras Mahogany; but the cuttings from Tabasco often realise fully 20 per cent. more.

and is used most extensively in that way. It therefore supplements the supply of Honduras, the deliveries of which of late have been scarcely sufficient to meet the growing demands for it.

TABLE CIV.—MAHOGANY (MEXICAN).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·00	3·50	720	790
2	1·25	·10	4·25	700	612
3	1·00	·05	4·25	920	715
4	1·00	·00	3·65	785	665
5	1·25	·15	3·75	880	660
6	1·00	·05	4·15	690	625
Total . .	6·75	·35	23·55	4,695	4067
Average .	1·125	·058	3·925	782·5	677·83

REMARKS.—Each piece broke short.

TABLE CV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	665	15,680	3,920
8	2 × 2 × 30	660	15,120	3,780
9	2 × 2 × 30	625	10,640	2,660
10	2 × 2 × 30	612	10,304	2,576
11	2 × 2 × 30	715	16,800	4,200
Total . .	...	3277	68,544	17,136
Average .	...	655	13,709	3,427

TABLE CVI.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	2·875	11·500	22·500	38·500
16—19	2·375	9·500	24·000	38·125
20—23	2·250	10·625	22·125	37·500
24—27	2·250	10·500	23·125	39·125
Total . .	9·750	42·125	91·750	153·25
Average .	2·437	10·531	22·937	38·312
Do. per in.	2·437	2·633	2·549	2·394

Nos. 28 and 29.

	Inches.		Tons.	Tons.	
One piece,	8·5 × 10 × 12,	crushed with the weight of	279·2	= 3·285	per sq. inch.
,,	8·5 × 10 × 21,	,, ,, ,,	245·5	= 2·887	,,

CUBA, HONDURAS, AND MEXICAN CEDARS

are varieties of the *Cedrela odorata*, but in their nature and condition of growth are very different from the genus *Cedrus*, the Cedar* of Lebanon, &c., which are conifers, and succeed best with plenty of room and in open grounds, whilst the "Cedar" wood trees of the West Indies and Central America appear to prefer a closer situation, and attain the greatest perfection in the forests. Many of these are very fine trees, capable of yielding well-squared logs of timber, 12 to 24 inches on the side by 18 to 40 feet in length, and even these dimensions are occasionally exceeded. Smaller timber is brought in considerable quantities into the market,

* See p. 210.

the whole finding a ready sale among cabinet-makers and with those engaged in the manufacture of cigar-boxes and similar articles.

TABLE CVII.—CEDAR (CUBA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·25	·05	4·35	530	372
2	2·35	·30	4·35	555	386
3	2·00	·25	4·25	630	530
4	2·25	·25	4·25	560	504
5	2·25	·35	4·35	550	416
6	2·50	·35	4·65	535	425
Total . .	13·60	1·55	26·20	3,360	2633
Average .	2·266	·258	4·366	560	439

REMARKS.—All broke with a short fracture.

TABLE CVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	416	11,760	2,940
8		425	11,200	2,800
9		504	12,320	3,080
10		530	10,640	2,660
Total . .	...	1875	45,920	11,480
Average .	...	469	11,480	2,870

TABLE CIX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 11.	No. 12.	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
8·00	7·75	9·00	7·25	32·00	8·00	2·00

The specific gravity of well-seasoned Cuba Cedar is about 439. The specific gravities of moderately-seasoned Cuba, Mexican, and Honduras Cedars are respectively 564, 640, and 664.

GREENHEART (*Nectandra Rodiæi*).

This tree, belonging to the natural order *Lauraceæ*, is found in Guiana, in the north-eastern portion of South America, and in the West Indies, and is an exceedingly valuable timber of perfectly straight growth, of from 24 to 50 feet in length, and 12 to 24 inches square.

Dr. Rodie detected in the bark of this tree an alkaloid called Bebeerine, which is used by the inhabitants of British Guiana as a remedy for fevers; and it is said, that when used as a substitute for quinine, it does not produce the headache and other symptoms found to follow the use of that medicine.

The wood is of a dark greenish or chestnut colour, the centre part being often nearly black; it, however, varies slightly, and the darker kinds are considered the best in quality. It is clean and straight in the grain, very hard and heavy, tough, strong, and elastic. In a transverse section it resembles a cane in being very full

of minute pores, and the concentric layers are only in rare instances distinguishable.

The heart-wood is considered very durable, and is generally believed to be proof against the ravages of the worm when used for piles, or other purposes under water, a property which would greatly enhance its value if it could be relied upon ; but its total immunity under such circumstances is doubtful.

Of the durability of the Greenheart timber, we have had sufficient evidence in the large stock of this wood kept in the royal dockyards, where it stood the test of many years' exposure to the weather, without being in any but the least degree affected by it. At Woolwich, the only place, I believe, where any attempt was made to protect it for preservation, the experiment to some extent failed, the ends of the logs splitting open rather more in the covered stacks than in those which were left exposed, while in other respects, there was absolutely no difference observable between the two parcels.

It is characteristic, however, of the Greenheart timber to split in this way, and to open clean across the pith in seasoning, there being frequently two such splits crossing each other at nearly right angles, and cleaving the log, at the end, into four segments; but these do not, usually, extend more than two or three feet up from the end.

This serious defect is, to some extent, compensated for by the fact that the logs do not split and form deep shakes along the sides in the seasoning, as do most other woods; so that there is not, after all, more than the ordinary amount of waste in the conversion of this kind of timber. Further, it is remarkable for its freedom from knots, and also for its general soundness, the only defect, beyond the splitting of the ends before mentioned, being a cross fracture of the longitudinal fibres, which is occa-

sionally seen, but can seldom be detected before the log is under conversion.

The alburnum, or sap of this wood, is of a dark greenish colour, and differs so little in appearance from the heart-wood, that it is often difficult to distinguish the one from the other. In quantity it is usually excessive, frequently amounting to a fifth, and sometimes even to a third, of the diameter of the tree. Few people, however, regard it when appropriating this timber to works of construction.

Owing to the difficulty of distinguishing the sap, many either dispute its presence altogether, or assert that if it exists it may be safely employed the same as the sap of Lignum Vitæ; this is, however, by no means certain, as I have found that if it is placed in any damp or imperfectly ventilated situation, it decays much sooner than the heart-wood; but if used under more favourable circumstances, its durability is very great.

In connection with this question, a merchant and importer of Greenheart timber said upon one occasion, when we had a parcel under survey, that he was confident a certain log had no sap-wood upon it, for if it had, it would be liable to the attack of a small worm, but that the worm would not touch the heart-wood. The log referred to was accordingly tested by cutting off a thin cross section, and upon examination of the piece, there were found in it several marks or traces of the worm, which had penetrated to the depth of 2 to 3 inches; the heart-wood, or duramen, had not, however, been touched. The gentleman at once admitted that, with such evidence, he would take it as conclusive that there was sap to the depth of 3 inches on the log, but that its appearance had entirely deceived him.

The case was no doubt exceptional, as the worm is very seldom seen in this wood.

Greenheart is extensively employed in ship-building for keelsons, engine-bearers, beams, shelf-pieces, &c., and for planking. It is also used for piles, and many other purposes, but its application to the domestic arts is somewhat limited by its great weight.

The strength of this wood exceeds that of most others, whether it be tried by the transverse or tensile strain, or by a crushing force in the direction of its fibres. Tried by the latter process, it exhibits a peculiarity unshared, I believe, by any other timber except Sabicu. It bears the addition of weight after weight without showing any signs of yielding; and, when the crushing force is obtained, it gives way suddenly and completely, with a loud report, nothing being left of the pieces but a loose mass of shapeless fibres.

The Greenheart timber is not usually hewn in the perfect manner that Teak, Mahogany, and many other woods are when prepared for shipment to the markets of this country, but comes from Demerara only partially dressed, a great deal of wane being left upon the angles. The butts are also almost invariably left with the snapped ends, as prepared for drawing out of the forest, instead of being cut off square. Its form should therefore be considered with the price quoted per load, as it will not compare favourably with well-squared timber.

TABLE CX.—GREENHEART (DEMERARA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific Gravity.
	Inches.	Inch.	Inches.	lbs.	
1	2·15	·05	5·00	1,235	1180
2	2·00	·00	4·75	1,656	1193
3	2·25	·15	4·60	1,305	1079
4	2·00	·00	5·00	1,212	1152
5	2·25	·15	4·15	1,258	1172
6	2·25	·05	4·25	1,329	1122
Total . .	12·90	·40	27·75	7,995	6898
Average .	2·15	·066	4·625	1,332·5	1149·6

REMARKS.—Nos. 1, 2, 3, and 6 broke with splintery fractures, 12 to 15 inches in length; 4 and 5 with similar fractures, but only 10 to 12 inches in length.

TABLE CXI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs
7	2 × 2 × 30	1152	31,920	7,980
8		1079	36,400	9,100
9		1193	37,520	9,380
Total . .	...	3424	105,840	26,460
Average .	...	1141	35,280	8,820

TABLE CXII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
10—13	7·00	27·000	57·125	93·150
14—17	6·75	27·362	58·000	92·875
18—21	6·75	27·750	57·250	92·625
22—25	6·50	27·000	56·875	93·500
Total . .	27·00	109·112	229·25	372·150
Average .	6·75	27·278	57·312	93·037
Do. per in.	6·75	6·819	6·368	5·814

TABLE CXIII.

Vertical Experiments.—Four pieces, Nos. 26, 27, 28, *and* 29, *each* 2 × 2 *inches, and respectively*

	1	2	3	4	Inches in length.
Crushed with	27·25	27·2875	25·875	25·862	Tons.

MORA (*Mora excelsa*),*

the product of Demerara and the island of Trinidad, is a Leguminous tree of straight growth, yielding timber in the log of 18 to 35 feet in length, and 12 to 20 inches square.

The wood is of a chestnut-brown colour, hard, heavy, tough, strong, and generally straight in the grain, but has occasionally a twist or waviness in the fibre, which

* Corrected to *Dimorphandra Mora* (Beuth) in the Kew Catalogue.

imparts to the logs possessing it a beautifully figured appearance, giving to them much additional value. As it takes a good polish, it would be useful as a substitute for Rosewood or dark Spanish Mahogany in cabinet-making, and might be employed for many purposes in the domestic arts.

The economical uses of the Mora are somewhat restricted by the frequency of star-shake in the logs, and only the best trees can be advantageously converted into plank and board; it may, however, be used with greater profit for beams, keelsons, engine-bearers, &c., in ship-building, and in a general way in large scantlings for either civil or naval architecture.

The Mora possesses great strength, and contains an oily or glutinous substance in its pores, which is probably conducive to its durability.

TABLE CXIV.—MORA (DEMERARA AND TRINIDAD).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·00	·10	4·75	1,353	1075
2	2·00	·10	5·00	1,363	1088
3	2·15	·15	5·00	1,304	1094
4	2·00	·05	5·00	1,284	1090
Total . .	8·15	·40	19·75	5,304	4347
Average .	2·037	·10	4·94	1,326	1086·75

REMARKS.—Each piece broke with about 12 inches length of fracture.

TABLE CXV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
5	2 × 2 × 30	1094	37,800	9,450
6		1090	37,240	9,310
7		1075	35,840	8,960
Total .	...	3259	110,880	27,720
Average .	...	1086	36,960	9,240

TABLE CXVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
14·875	14·750	14·875	15·750	15·750	15·500	91·50	15·25	3·812

The island of Trinidad also produces the Carapo (*Carapa guyanensis*) and the Balata trees, both of which attain moderate dimensions.

Sample logs of the Carapo timber were a few years since sent to Woolwich Dockyard, with a view to their introduction for ship-building purposes. The wood was red in colour, straight in the grain, of moderate weight and hardness, and somewhat resembled inferior Mahogany.

It had, however, a strong tendency to split and tear to pieces in seasoning, and in only a few months it was

so far deteriorated by shakes as to be unfit for almost any purpose in carpentry.

The wood of the Balata tree (*Mimusops globosa*) was dark red in colour—fine, close, and straight in the grain—hard, heavy, strong, and somewhat resembled the African timber of commerce, except that the centre of the logs was very shaky. Decay, with hollowness, had set in about the pith in some of the logs, indicating that it had commenced while the trees were still young, and otherwise strong and vigorous.

When the logs referred to had been kept for only a few months to season, the ends split open very much, and as these splits or shakes crossed each other at nearly right angles, and extended rapidly, they seemed likely soon to separate the pieces into four quarters, a serious defect which disqualified them for use in large scantlings, and rendered them only fit for some inferior purposes.

Judged by the samples of Carapo and Balata, it seems that neither are suitable for important works of construction; it is therefore doubtful whether any supplies will be now imported.

JUBA (*Erythroxylon*)

is found in Havana. Two sample pieces of plank, cut from the Juba tree, were sent by the Consul-General in Cuba, in 1858, to the Admiralty, with a view to the introduction of this wood into the royal dockyards for ship-building purposes.

It was understood they were forwarded at the request of Mr. Donald, a gentleman of considerable experience in the timber business, who was of opinion that it would be found a useful wood. He reported that the tree

attained the same dimensions as the Sabicu, and that it could be supplied in large quantities. It, therefore, appeared to be well worth a consideration, as the importation of Sabicu timber was very limited, and scarcely equal to the demand for it.

The samples referred to, upon examination at Woolwich, were found to have been cut from small trees, but so far as could be judged from their appearance, the timber was suitable for use in architecture, and would probably be useful in the domestic arts.

The wood of the Juba tree is yellow in colour, hard, heavy, strong, close in the grain, and apparently would work up well. The specific gravity is about 1072.

I have not been able to ascertain that it has ever been brought upon the London market, and think it likely its uses are chiefly confined to the island of Cuba.

SABICU (*Lysiloma Sabicu*),

known also as *Savicu*, is a native of the West Indies, and is plentiful in Cuba. Its growth is somewhat crooked and irregular, but it yields excellent timber of from 20 to 35 feet in length, and from 11 to 24 inches square.

The wood is of a dark chestnut colour, hard, heavy, strong, close in the grain, and is often twisted or curled in the fibres, which gives it a wavy, or, as it is technically termed, a figured appearance, imparting to it a rich dark colour, which resembles and is sometimes mistaken for Rosewood. It is often on this account of considerable value, and being capable of taking a high polish, is much prized by cabinet-makers and others who employ it for furniture, &c.

The Sabicu has very little sap, and is a remarkably solid wood. It is characteristic of it that there is an almost complete absence of the heart, star, and cup-shakes. It seasons slowly, shrinks but little, and does not split, as do most other woods, while undergoing that process. It also bears exposure to the weather without being in any but the slightest degree affected, even if left without either paint or varnish to protect it; further, it works up well, and there is only a trifling loss in its conversion. Therefore, as this wood is known to be durable, it has much to recommend it to the favourable notice of the manufacturer.

There is one defect, however, occasionally met with in the Sabicu, which must be set against the good qualities before mentioned, as it is more common to this than to any other timber with which we are acquainted. This is a cross fracture of a very remarkable kind, and of the greatest importance, from the fact that it can rarely be detected until the log is in process of conversion. It is then sometimes found that the longitudinal fibres of the early and middle period of the tree's existence are completely broken, while the outer woody layers of both the duramen and alburnum are perfect. This defect will sometimes occur in several places in the same tree.

It is difficult to conjecture the cause of this, since it cannot, one would think, be done by the concussion in the fall of the tree, as that would, if any injury were done, produce a more extensive fracture than has been noticed; one which would be apparent upon a superficial examination of the surface. I therefore incline to the opinion that it is produced by the storms and hurricanes that occasionally sweep over the island, swaying the trees to and fro, and snapping the longitudinal fibres of the stem, without breaking them completely off; the

later growth apparently strengthening, and most effectually covering the defect.

It may, however, be well to state, that in offering this opinion of the cause of the cross fracture in Sabicu timber, the same does not appear to affect the Mahogany and other trees, the produce of Cuba, since no instance of this peculiar defect has been found.

Sabicu is used in ship-building for beams, keelsons, engine-bearers, and stern-posts, and for pillars, cleats, &c. Officers have, however, hesitated to employ it for beams which are intended to carry heavy guns, lest it should contain some hidden defect of the character just mentioned. It is only sparingly used in works of civil architecture, on account of its great specific gravity.

TABLE CXVII.—SABICU (CUBA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·00	·00	3·25	1,090	936
2	1·00	·10	4·10	1,510	928
3	1·00	·05	3·15	1,090	899
4	·85	·00	4·25	1,390	910
5	1·00	·05	3·50	1,280	923
6	·90	·00	4·25	1,395	904
Total . .	5·75	·20	22·50	7,755	5500
Average .	·958	·033	3·75	1,292·5	916·66

REMARKS.—Nos. 1, 4, 5, and 6 broke with about 10 to 11 inches fracture; 2 and 3 broke with 8 inches fracture.

TABLE CXVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	923	17,360	4,340
8		904	24,360	6,090
9		910	22,120	5,530
10		936	21,280	5,320
11		899	20,776	5,194
12		928	27,496	6,874
Total . .	...	5500	133,392	33,348
Average .	...	916·66	22,232	5,558

TABLE CXIX.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	3·000	15·875	36·625	61·75
17—20	3·250	16·750	36·500	63·75
21, 22	3·125	16·000		
23, 24	2·875	14·750		
Total . .	12·25	63·375	73·125	125·50
Average .	3·062	15·844	36·562	62·75
Do. per in.	3·062	3·961	4·06	3·922

LIGNUM VITÆ (*Guaiacum officinale*),

one of the *Zygophylleæ*,* is found on several of the West India Islands, and in many other places, but the chief supplies come from St. Domingo and Bahama. It attains, in the former, the diameter of 22 inches, and some 30 to 40 feet in length; but the Bahama is generally very small.

The wood is dark brown, or rather greenish black, in colour, very hard, heavy, strong, and close and wiry in the grain; it is difficult to work in any fashion, but there is nothing equal to it for the making of sheaves for blocks, and when employed in this way it wears well, and seems almost imperishable. I have examined some sheaves after they have been in use for 50 to 70 years, and found them perfectly good, and fit for further service.

The sap-wood is yellow in colour, ¾ to 1 inch in thickness, and, like the sap of English Elm, is of such exceptionable character, that it is equally as good and durable as the heart-wood. In sheave making, a belt of this sap-wood is, if possible, left on to preserve the rest of it from splitting. The chief defect in Lignum Vitæ is the cup-shake, and this occurs rather frequently in the wood of 10 inches and upwards in diameter; it is, therefore, often difficult to obtain a sufficient supply of the larger sizes suitable for the block-maker, who must have not only the roundest, but also the most solid, wood for his purpose. There are many demands, however, for this wood for less important services, and all that comes finds a ready sale.

Lignum Vitæ is imported in the round state, and in very short lengths; pieces under 10 inches diameter are usually in lengths of 6 to 12 feet, and the larger wood in

* A totally different wood, yielded by a species of *Ixora*, goes by this name in British Guiana.

lengths of 3 to 6 feet. It is commonly sold by weight, and realises from £6 to £18 per ton, according to size and quality. That from the city of St. Domingo is the best. The specific gravity is 1248.

ROSEWOOD (*Triptolemæa*).

The name Rosewood is applied to very different timbers in various parts of the world. West Indian Rosewood, of the best kind, appears to be the timber of *Dalbergia nigra*, but there is little doubt that several allied species are thus denominated, *e.g. Machærium*—the Iacarandas of Brazil.

African Rosewood is *Pterocarpus erinaceus*, and in India the wood of *Dalbergia latifolia* is thus named, as in Burmah is that of *Pterocarpus indicus*. In Australia species of *Acacia*, *Dysoxylon*, *Eremophila* and *Synoum* go under this name, some of them, however, on account of their scent, and not their resemblance to the cabinet-makers' wood. Canary Rosewood is *Rhodorhiza scoparia*, and the *Cordia Gerascanthus* of Dominica receives the name. *Amyris balsamifera* and others are also so called in the West Indies. Further information as to the Rosewood is much wanted.

It is found in Jamaica, Honduras, Bahia, Rio, and San Francisco. It attains large dimensions, but is often faulty in the centre, owing to decay setting in long before the tree reaches maturity.

The wood is dark chestnut, or brown, in colour, streaked or veined, and generally figured in the grain; it is hard and heavy, but in the hands of the cabinet and pianoforte makers it works up well; it is highly valuable for all kinds of ornamental work, and for many purposes in the domestic arts. It takes a good polish.

The chief defect in this wood is heart-shake, or hollowness at the centre, which extends far up the tree, and this necessitates the cutting of the logs down the middle longitudinally; often a middle piece is wasted on this account, consequently we never see sound solid square logs, or even plank, but generally half-round flitches, 10 to 20 feet in length, and varying from 5 to 12 inches in the thicker part, put upon the market, the inside or sawn surface being even then frequently deficient of wood in the centre, exhibiting in part the hollowness pertaining to the tree.

Solid round Rosewood logs beyond the medium size, or 14 inches in diameter, are extremely rare, and the best that I have met with were brought from San Francisco. Owing to the difficulty there is in measuring half-round flitches of the nature and form herein described, this wood can only be sold by weight. It realises, for the inferior, £10 to £12, and for the good, £20 to £30 per ton; the superior qualities fetch much higher prices.

The following woods, the growth of French Guiana, were selected under a commission appointed by the Colonial Government of St. Laurent du Maroni. They were imported into Havre only recently (1874).

1. Angélique. This tree is of straight growth, and yields timber 12 to 22 inches square, by 20 to 54 feet in length, clear of branches.

The wood is of a reddish-brown colour, clean and even in the grain, moderately hard, tough, strong, elastic, and not difficult to work, although it does not cleave readily. Occasionally a few logs are found with a waviness or figure in the grain, which would make them valuable to the cabinet-maker. There is little sap-wood.

The timber is very sound and free from knots, and,

except that a small percentage of the logs have a slight heart, or perhaps, star-shake at the pith or centre, there are no defects affecting the conversion of it into planks, boards, &c., as may be required. This wood, therefore, seems fit for employment in architecture for most of the purposes to which African Mahogany, Oak, Teak, Sabicu, &c., &c., are used.

It is reported to have been used for some time in the French dockyards as backing to armour plates on ships, and as it does not appear to contain any acid it might be employed in lieu of Teak for a similar purpose in England. It has been said that it does not rot in water, that it is proof against attacks from many insects to which other timber is liable, and that it is durable. The specific gravity is estimated to be about 770 to 820 when seasoned.*

2. Balata. (See p. 278.) This wood is of a yellowish colour, hard, heavy, strong, plain in grain, with slight heart-shake at pith or centre. It appears to be of good quality, and fit for employment in architecture in lieu of other hard wood, or it might be used for furniture. The sample logs were 13 to 18 inches square, by 20 to 24 feet in length.

3. Ébène. This wood is greenish in colour, very hard, heavy, strong, plain and even in the grain, solid, and good in quality. The sap-wood is about 1½ inch thick. It would be useful in turnery, or for any of the

* Since the above was written, an opportunity has offered of practically testing a few logs of partially seasoned Angélique timber, s. g. 916. They opened very sound, and were tough, strong, and elastic. There was very little waste in the conversion—in reducing it to planks, &c. In working, however, it was found that some of the logs emitted an unpleasant odour, and —unless in seasoning the odour should evaporate—this may possibly prove detrimental to its value for general purposes, perhaps for the inside of ships, or in close, damp places.

purposes to which the common or Ceylon Ebony is applied.

4. Ébène rouge. This wood is of a dark reddish colour, hard, heavy, strong, and straight in the grain, but is scarcely so solid at the centre as the last-mentioned wood. The dimensions of two sample logs were 12 to 14 inches square, by 14 to 17 feet in length. Both had cup-shakes at the ends. The uses for this wood would be similar to No. 3.

5. Grignon. This wood is red in colour, moderately hard, close and plain in the grain, and solid. It is of good quality, and fit to be employed in civil architecture, or in the domestic arts. The dimensions of sample logs varied from 14 to 17 inches square, and 14 to 27 feet in length.

6. Maconatari. Only one out of six pieces sent could be identified; it was dark in colour, hard, and heavy. The dimensions given for the parcel varied from 14 to 20 inches square, and 14 to 23 feet in length.

7. Paccouri Soufri. This wood is of a reddish-yellow, or brimstone colour, of a moderate degree of hardness, straight in the grain, and disposed to split freely in seasoning. Three logs were sent as samples, and each had injurious heart and cup-shakes. The dimensions were 19 to 22 inches square, and 14 feet in length: longer timber could no doubt be obtained if it were worth while, but it seems to be only fit for very inferior purposes.

8. Rose mâle. This wood is of a yellowish colour, moderately hard, heavy, and straight in the grain. Only one sample log was sent; the dimensions were 12 inches square, and 14 feet in length, both ends were covered with wood clamps, which was probably done to hide a faulty centre. It appeared to be only fit for inferior purposes.

9. Rose femelle. This wood, like the preceding, is of a yellowish colour, hard, of moderate weight, and straight in the grain. Only one sample log was sent; the dimensions were 16 inches square and 14 feet in length, and this was touched with incipient decay at the centre. Like No. 8, it appeared to be only fit for inferior purposes.

10. Simarouba. This wood is light in colour, moderately hard, plain and free in the grain, and splits rather seriously in seasoning. The quality is not good, it therefore could only be used for inferior purposes. The dimensions of the logs varied from 14 to 16 inches square, and 13 to 14 feet in length.

11. Satiné. This wood is red in colour, hard, heavy, solid, and of good quality. It might be employed in either naval or civil architecture in lieu of other hard wood, and also for cabinet work, turnery, &c., &c. The dimensions of the logs varied from 13 to 15 inches square, and 14 to 28 feet in length. The sap-wood left upon the angles appeared to be about 1½ inch thick.

12. St. Martin. This wood is red in colour, hard, heavy, close and straight in the grain, and of good quality. It might be employed in either naval or civil architecture in lieu of other hard wood, and would be valuable for furniture and other purposes. The dimensions of the two sample logs were 17 and 20 inches square, and 27½ feet in length.

13. Violet. This wood is of a violet colour, very hard and heavy, close and fine in the grain, and solid. The quality is very good, and therefore it is likely to be highly prized by the cabinet-maker, turner, and others. The dimensions of the logs were 11 and 13 inches square, and 24 feet in length.

14. Wacapou. This wood is brownish in colour, straight, and clean in the grain, of moderate hardness

and weight, and inclined to split or shake rather seriously from the pith or centre. It would not, therefore, be of much value for architectural purposes, but in the domestic arts it could be turned to account in many ways. The dimensions of the logs varied from 13 to 16 inches square, and from 14 to 21 feet in length.

15. Wacapou gris. This wood is darker in colour than the preceding, and has a slight resemblance to Rosewood, but is upon the whole pretty much of the same character as the Wacapou, and of no value except perhaps for the plainer description of cabinet work. The dimensions are the same as No. 14.

16. Ébène verte. This wood is dark green in colour, very hard, heavy, close in the grain, solid, and of good quality. Like No. 3, it has about 1½ inch of sap-wood. The dimensions of the logs varied from 14 to 16 inches square, and were about 14 feet in length. It would be chiefly used in cabinet work and turnery.

17. Boco. This wood is dark in colour, hard, heavy, straight, and of good quality. It might be useful in architecture as an article of general applicability in place of other hard and strong wood, or to the cabinet-maker for furniture, &c., &c. The logs were delivered at the docks in Havre in a round state, and were about 18 inches in diameter, and 29 feet in length.

18. Panacoco. This wood is dark in colour, hard, heavy, straight, and of good quality, the sap-wood being about 1⅝ inch thick. It might be used as a substitute for other hard wood in architecture, or for general purposes. The sample log was in a round state, 17 inches diameter, and 32½ feet in length.

All the woods, from 2 to 18 inclusive, were readily taken by the Parisian and local dealers at Havre for cabinet and other purposes, and realised good prices.

A great many specimens of other woods growing in the French colony at Guiana were also sent with the foregoing; but as they were quite small pieces it was difficult to judge of their fitness for employment in architectural or other works. Probably before long some of these may be supplemented by sample logs, similar in dimensions to Nos. 2 to 18, and if so, a better estimate may be formed of their commercial value.

SANTA MARIA (*Calophyllum Calaba*)

is found in Honduras, in Central America, but is not considered to be abundant; and very little of it finds its way to the markets of this country. It is of nearly straight growth, and attains the height of 60 to 90 feet, with a circumference of from 7 to 9 feet, yielding very fine logs, measuring from 25 to 50 feet in length and from 12 to 22 inches square.

The wood is of a pale reddish colour, moderately hard, has a clean fine straight grain, and is a little porous. It is generally free from injurious heart or star-shake, has few knots, does not shrink much, and scarcely splits at all in seasoning. It is easily worked, and may therefore be considered a very fair substitute for the plainest Honduras or Mexican Mahogany. Some few years since several cargoes of Santa Maria timber were brought to the royal dockyards, and employed there for beams, planking, &c., in ships; and although it would seem never to have been much in favour as a building wood, there is good reason to think that in the absence of Mahogany it might very well be used for cabin fitments, for furniture, and many other purposes.

This wood stands exposure to the weather remarkably well, and is, I think, durable, since a parcel of about 150

loads which I inspected after it had been left in the open in a moist country for about ten years, showed scarcely any signs of deterioration either at the centre or at any other part, and had but few shakes on the external surfaces.

The specific gravity is about the same as Honduras or Mexican Mahogany.

Southwards from Central America there are to be found, in the forests of the Brazilian Empire great varieties of timber trees, many of which are no doubt of good quality and fit for architectural purposes, but little or nothing is known of them in this country. I therefore take the present opportunity to place before the reader a brief description of some twenty-four of them, with their uses; observing that specimens of these woods, 3″ × 3″ × 1″, were sent to the Admiralty in 1858, by H.B.M.'s Consul at Rio de Janeiro, with the view to the introduction of some of them for employment in ship-building.

Angelim-vermetho. The wood is reddish brown in colour, and moderately heavy. It is probably of crooked growth, as it is used for ship-timbers in the Brazilian dockyards. Judged by the specimen, this appears to be of good quality.

Incaranda-tan. The wood is reddish in colour, close-grained, and fit to be employed for furniture and ornamental work. It is used for these purposes, and might be made available for architectural works, as it appears to be of good quality.

Securipa. This is a brown-coloured wood, of moderate weight, and fair quality. It is believed to attain large dimensions, and being of straight growth, it would convert well into planks, boards, and scantlings, for

employment in architecture. It is used for planking and beams in ship-building.

Guarabu. The wood is puce-coloured, and fine in grain; its pores, which are very numerous, being filled with a hard white substance. It is stated to be of straight growth and large dimensions, and would therefore be applicable to naval and civil architecture, as well as other purposes. It is used in ship-building the same as the Securipa.

Macaranduba. The wood is red in colour, close-grained, strong, and heavy. It is occasionally used for ship-building in the Brazils; and, if the dimensions are suitable, it probably would be found available for architectural works, as it appears to be of good quality.

Meriquitiara. A reddish-coloured wood, moderate in weight, and apparently of good quality. If it attains to large dimensions it might be employed for architectural purposes. It is used for ornamental work in the Brazils.

Pao-de-Pezo. A hard, dark, and heavy close-grained wood, resembling Lignum Vitæ. It may be adapted for blocks and sheaves, and, judging from its appearance, is well suited to those purposes.

Peroba-parda. This is a brown-coloured wood, light, with a fine, straight grain. It attains moderate dimensions, and is used in ship-building.

Peroba-branca, or P. de Campos. The wood is yellow in colour, of moderate weight, close and fine in the grain, and not difficult to work. It takes a high polish. It attains large dimensions, and is fit for employment in architecture, for furniture, and generally in the domestic arts. A sample of this wood, 6″ × 18″ × 10′, measuring 7½ cubic feet, was sent to

the Admiralty a short time since, with this description, viz.: "Produced in square logs of about 24 inches siding and 60 to 70 feet in length. Sound timber of 30 to 40 inches square is common. The tree is of straight growth, is stronger than Teak, agrees well with iron, and is very durable. The specific gravity is ·868. Brazilian ironclads are built with it."

Peroba-vermetho. The wood is red in colour, and has a smooth, close, fine grain; it is of moderate weight, and resembles, in a slight degree, Pencil Cedar. It was stated with reference to the Peroba-parda, the Peroba-branca, and the Peroba-vermetho trees, that they were "the principal woods adapted for ship-building purposes, being the largest and the lightest, the weight being about 50 lbs. to the cubic foot. Large sizes of these can be obtained, but only at a great expense. The Peroba-branca is more plentiful than the others, is equally good, and better adapted for spars. It floats about the same as Pitch-pine. Peroba is stronger than Teak, but not so heavy."

Grapiapunha. This is a yellowish-coloured wood, with a clean, free, straight grain, moderately heavy, strong, and one of the most useful woods for planking or timber. It attains only medium dimensions, but may be turned to account in many ways in the domestic arts, although, judging from the appearance of the specimen, it did not impress me as being of the best quality.

Tapinhonho. The wood is light brown in colour, porous, with a clean, free, straight grain, moderately heavy, and is used for frame-timbers in ship-building. It attains only moderate dimensions, and is probably of crooked growth.

Piquea-marfim. The wood is of a bright yellow

colour, close and fine in the grain, and would work up well, taking a high polish. It is similar to Satin-wood, but scarcely so hard or so heavy. It is chiefly used for ornamental work, for which it appears to be very suitable.

Canella-preta. The wood is brown in colour, straight in grain, light, and easy to work. It is of straight growth, and attains considerable dimensions. It is used for decks in ships, and in house-building and carpentry generally; but, when old, it becomes soft and spongy, and is considered not to be durable.

Jenipapo. This is a light-coloured porous wood, having a clean, straight grain. It works up well, and is employed in carpentry and the domestic arts; it is also used for planking in ships, but it does not appear to be of a durable character.

Camara. This is a light-coloured wood, strong, moderately heavy, of small growth, and is used principally for boats' timbers.

Peguy. The wood is light brown in colour, straight in grain, porous, moderately heavy and strong. It attains medium dimensions, and is used for planking in ships, and for many purposes in carpentry.

Arariba-ou-potumuju. This is a light-coloured wood, with a clean, straight grain. It works up well, and is chiefly employed in the domestic arts. The quality is considered to be inferior.

Arariba-roza. The wood is red in colour, and has a fine, straight, close grain; it is very light, and is used for furniture and cabin fittings. It attains only moderate dimensions, and is probably a dye wood.

Cedro. This is a light-coloured and very porous wood, of quick growth, and apparently of inferior quality. It is probably a species of Cedar.

Mangalo. This is a brown-coloured, porous wood, strong, and moderately heavy. It is used for beams in ship-building, in carpentry, and in the domestic arts. Judged by the specimen, the quality appears to be fair, but little is known as to its durability.

Pao-setim. The wood is bright yellow in colour, with a clean, fine, straight grain; looks as if it would work up well, and is chiefly used for the manufacture of small wares.

Jacaranda-cabiuna. This is a dark-coloured, porous, open-grained wood; in appearance it somewhat resembles an inferior quality of Rosewood. It is of moderate weight, and works up well for furniture and for ornamental purposes.

Vinhatico. The wood is yellow in colour, light, open-grained, and is probably of inferior quality. It appears to be a species of Cedar, and is used by the cabinet-maker, and for many purposes in carpentry.

In addition to the foregoing, the following West Indian Timbers may be mentioned, though little is known of them out of the Islands.*

The Jamaica Cogwood, the most durable wood for mill-work, &c., under water, yielded by *Zyzyphus Chloroxylon*, a species of Rhamnaceæ.

Cedrela odorata. See p. 268.

Copaïfera hymenæifolia is a Cuban tree yielding large building timber in the lowlands, and known there as Cagüeyran.

JAMAICA.

Red Muskwood, *Guarea* or *Moschoxylum Schwartzii.*

* Much information is still needed regarding West Indian timbers and their names. The new catalogue of the Kew Museum, No. 3, published since this list was drawn up, should be consulted for further details not included here. See also Reports of the Indian and Colonial Exhibition.

Ironwood, *Erythroxylon acreolatum.*

"Birch," *Bursera gummifera.*

Green Ebony, *Brya ebenus.* A valuable cabinet wood.

Yacca, *Podocarpus coriaceus.* A cabinet wood.

TRINIDAD.

Balata, *Mimusops globosa* (Sapotaceæ). A good building wood.

Black Cypre. A species of *Cordia.*

Bois Lezard, *Vitex divaricata.*

Chairwood, *Tecoma leucoxylon.*

Cordia Cerascanthus. A somewhat important timber in the colony.

Lignum Vitæ. See p. 283.

Locust, *Hymenæa Courbaril* (Leguminosæ). A large tree, with close, hard, and very beautiful timber, used for engineering works.

Mora. See p. 275.

Roble, *Platymiscium platystachyum.* Used for ships.

Yoke, *Piptadenia peregrina.*

ST. VINCENT.

Water-wood, *Chimarrhis cymosa.* A valuable joiners' wood.

ST. LUCIA.

Satin-wood, ? *Maba guianensis* (Ebenaceæ). Used for furniture.

Savonette, *Pithecolobium micradenium.*

ANTIGUA.

Mastick, ? *Bursera gummifera.*

DOMINICA.

Bullet-wood. Same as Balata (p. 296).

Angelin, *Andira inermis.* A durable building and engineering timber.

Bois Riviere, *Chimarrhis cymosa* (p. 296).

BARBADOES.

Fiddle-wood, *Citharexylum melanocardium* (Verbenaceæ). Carpentry and wheelwrights' work.

GRENADA.

Dog-wood, *Piscidia Erythrina* (Leguminosæ). Building.

Galaba. If this is the Galba of Trinidad (*Calophyllum Calaba*) it is an excellent and durable timber. See *Santa Maria* (p. 290).

Sapodilla, *Achras Sapota.* Furniture, cabinet-work, &c.

BAHAMAS.

Sabicu, *Lysiloma Sabicu* (Leguminosæ). Valuable for ship-building, imported from Cuba. See p. 279.

Braziletto, *Cæsalpinia crista.* Cabinet work. And *C. brasiliensis.*

Horseflesh. An allied species of *Cæsalpinia.*

BRITISH HONDURAS.

Yellow or Pitch Pine, *Pinus cubensis.* Yellow, carpentry.

Rosewood, *Dalbergia.* Pianos and cabinet.

Palmalatto or Zebra-wood, *Connarus guianensis,* an elegantly marked furniture and cabinet wood.

Santa Maria, *Calophyllum Calaba.* Large, yellow, close. Structure and ships. See p. 290.

Fustic, *Chlorophora tinctoria.* A light durable timber, suitable for carriage work and furniture.

Iron-wood, *Laplacea hæmatoxylon*, hard, and used for cogs.

The following also belong to Honduras, and are for the most part undetermined:—

Button-wood, ? *Cephalanthus occidentalis.* Cabinet.

Granadilla. Red, hard. Building and furniture.

Information is wanted about the following and other West Indian timbers: Tacca, Dago, Lancebark, Red Blue Heart, Sceiti, Tappana, Zambosa, Cazon, Dibasse, Acacia, India Oak, Razor Strop, Mawbee, Bois Cassava, Lauriet-zabella, Red Zammier, Axemaster, Blackheart, Chechem, Drunken Bayman, My Lady, Redwood.

CHAPTER XXV.

AFRICAN TIMBERS.

NO large division of the globe is so little explored in respect of its Timber as the African Continent, and beyond a few regions such as the Cape and Natal, parts of the West Coast, and a few others, we are almost uninformed as to the supplies or values of the native woods for the purposes of Europeans.

The best known of African woods is the

AFRICAN OAK OR TEAK.*

The African Oak tree, the African Teak (*Oldfieldia africana*), is yielded by a species of Euphorbiaceæ. It has been known under a variety of names, and confounded with Mahogany under the name of *Swietenia Senega-*

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* Cape Teak, or Cape Oak, is an unimportant South African wood, referred to variously as *Strychnos*, *Atherstonea*, and *Canthium*, and has nothing to do with this timber. The term "Oak" is misapplied in different parts of the world. As usual, the Australian colonists have done this largely, numerous species of *Casuarina* (see p. 252) being thus designated; but settlers in various other parts of the world have given the name to many other trees having nothing in common with true Oaks. Thus *Catalpa longissima* goes by this name in St. Domingo, and in Dominica *Ilex sideroxyloides*, in New Zealand *Alectryon excelsum*. The Ceylon "Oak" is *Scheichera trijuga*.

lensis, or *S. Khaya*, and is brought from Sierra Leone, and resembles in properties the Oaks of Europe and America and the Teak of India, largely the characteristics of both species, but much heavier and harder to work.

The tree is of straight growth, and the height, as estimated from the logs imported, must be at least 30 to 40 feet clear of the branches, with a circumference of from 7 to 8 feet. This wood is of a dark red colour, very hard, strong, rigid, and difficult to work or cleave; it has a fine, close, straight grain, is of remarkable solidity, has no injurious heart-shake, and shakes of the cup or star kind are extremely rare in it; the centre wood,

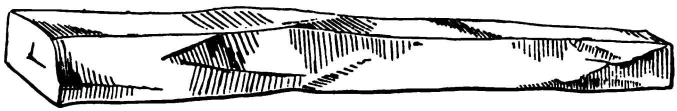

FIG. 27.

about the earlier concentric circles, is close and very compact, differing less from the outer layers in texture than in most other trees. In seasoning this timber shrinks very little, it rarely warps, and stands exposure to the weather a long time without opening with surface shakes, or sustaining any apparent damage.

African timber, possessing, as it does, so many good properties, is employed in ship-building for beams, keelsons, riding bitts, stanchions, &c., and in a variety of ways; but in civil architecture, and in the domestic arts, it is only sparingly used, on account of its weight.

This timber is brought upon the market in very roughly-hewn logs, intended, no doubt, to be square,

but varying considerably from that form, and taking, generally, the most irregular shapes (Fig. 27). Sometimes they are angular, at other times they have a thick and a thin edge, resembling, in some degree, a "feather-edge" board; again, we find they are neither tapered to the natural growth of the tree, nor made parallel longitudinally, but vary in thickness in that direction, leading to a most serious waste of the raw material in the neglect to preserve the fullest-sized square log obtainable from the tree.

It will naturally be inferred that, being thus awkwardly shaped, it is the most difficult of all timber to measure correctly.

TABLE CXX.—AFRICAN (AFRICA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·25	·10	5·50	1,301	982
2	2·50	·05	4·25	971	1086
3	2·50	·05	5·75	1,231	1008
4	2·00	·00	5·35	1,086	988
5	1·75	·00	4·75	1,014	934
6	2·50	·10	5·25	1,046	962
Total . .	13·50	·30	30·85	6,649	5960
Average .	2·25	·05	5·142	1,108·16	993·3

REMARKS.—Nos. 1, 3, and 4 broke with a long fracture; 2, 5, and 6, short, but fibrous.

TABLE CXXI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	982	30,800	7,700
8	2 × 2 × 30	1008	43,400	10,850
9	2 × 2 × 30	934	19,040	4,760
10	2 × 2 × 30	962	19,600	4,900
Total . .	...	3886	112,840	28,210
Average .	...	971·5	28,210	7,052

TABLE CXXII.

Vertical Experiments on cubes of

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	5·013	18·625	39·5	64·0
15, 16	4·875	17·875	—	—
17, 18	4·875	18·500	—	—
19, 20	4·937	18·000	—	—
21, 22	4·875	18·500	—	—
23, 24	4·875	18·250	—	—
Total . .	29·450	109·75	—	—
Average .	4·908	18·292	39·5	64·0
Do. per in.	4·90	4·573	4·388	4·0

TABLE CXXIII.

Vertical Experiments.

Number of the specimen.	Dimensions of the pieces.		Specific gravity.	Crushed with	Do. on the square inch.
	Inches.	Length. Inches.		Tons.	Tons.
25	2 × 2	1	993	17·000	4·250
26		2		18·292	4·573
27		3		18·875	4·719
28		4		18·125	4·531
29	3 × 3	7	...	39·500	4·390
30		8	...	38·500	4·277
31		11	...	35·500	3·944
32		12	...	36·000	4·000
33	4 × 4	17	...	63·000	3·938
34	9 × 10	24	...	433·200	4·811

The principal dicotyledonous timbers of South Africa are:—

Stink-wood (*Ocotea bullata*), yielding a timber not unlike Walnut and regarded as a substitute for Teak, and which emits a strong and peculiar odour when worked.

Sneeze-wood (*Pteroxylon utile*), perhaps the most valuable large timber in Cape Colony and Natal. The name is said to be due to the irritant action of the dust given off in working. Large logs can be obtained, and the grain is very beautiful, somewhat resembling Satin-wood. It contains a gum-resin like substance, and burns briskly. Unfortunately it is extremely hard and difficult to convert, drawbacks which, together with its irregularities of growth, must be set off against its undoubted value as a durable and handsome wood for many purposes of engineering, carpentry, and cabinet work.

Assegai-wood (*Curtisea faginea*), a bright red, close, tough furniture wood.

Candeboo Stink-wood (*Celtis Kraussiana*), dark greenish, beautifully veined, and very hard.

Essen-wood or "Ash" (*Ekebergia capensis*), an easily worked, pale yellow timber of poorer quality than the European Ash, to which it has resemblance.

Black Iron-wood (*Olea laurifolia*), dense, close-grained, and heavy, but beautifully figured and good for turnery.

White Iron-wood (*Toddalia lanceolata*), moderately hard, elastic wood, used for wheelwrights' work and general purposes.

Red Stink-wood (*Brabejum stellatifolium*), a dark-coloured wheelwright and cabinet wood of moderate size.

Boxwood* (*Buxus Macowani*), a small dense Box, recommended as a substitute for true Box.

Wild Chestnut (*Calodendron capense*), a light-coloured, fairly hard, tough and strong wood, useful for waggon work, &c., and said to be suitable for sleepers, but condemned as inferior by some authorities.

Red Els (*Cunonia capensis*), a hard, tough and fairly light timber, of good quality and of a rich red colour, useful for furniture work, and said to be durable in water.

Saffron-wood (*Elæodendron croceum*) is a beautifully-grained furniture wood, somewhat like Walnut; also useful for boat-building, wheelwright and general work. It is heavy, hard and tough, and durable, and said to be useful for coarser engraving.

Cape Ebony, a species of *Euclea*, of the same family as the true Ebony, is a very hard jet-black wood, suit-

* Boxwood is a term commonly applied to several different trees in the colonies. Various species of *Eucalyptus* go under this name in Australia, and in Tasmania *Bursaria spinosa* is thus termed. American Boxwood is *Cornus Florida*; Jamaica Boxwood is *Tecoma pentaphylla*; while in other parts of the West Indies *Vitex umbrosa* receives this name. *Buxus Macowani* is the Boxwood of the Cape, but *Gonioma Kamassi* receives the same name.

able for fancy work; one or two other species of the genus are used at the Cape, of which the hard, brown, beautifully-figured Quar is the most important.

Other South African timbers of note are the White Milkwood (*Sideroxylon inerme*), the Wild Olive (*Olea capensis*), the Red-wood (*Ochna arborea*), and a kind of Boxwood (*Gonioma Kamassi*), reported as valuable for turnery work and engraving.

We have no very extensive knowledge of the woods of Western Africa, and that to which I have just referred is probably the only useful tree known to commerce in the markets of this country. At the Cape I obtained specimens of the Els and Red Els wood, the light, dark, and grey Stink-wood, and the Yellow-wood, and understood that all these grew to moderate dimensions, and were useful for building and domestic purposes in the colony; but as there were none within easy reach of Cape Town, or then available for exportation, no opportunity was afforded of judging from any large parcel of either as to their real merits.

A few years since Mr. Macleod, formerly H.B.M. Consul at the Seychelles Islands, procured a great many specimens of wood from the district of the Zambesi, and sent them to the Admiralty.

Annexed is a list of twenty-six varieties, with their names and the dimensions the trees are supposed to attain, as also their uses as given by Mr. Macleod; observing that where an opinion of the quality is stated, it is the best that I could form from small pieces of $3'' \times 3'' \times 1''$.

Some few of these would certainly be fit for any architectural or other works, but we have no information as to their abundance or otherwise, or even whether they could be easily brought out from the forests to a port of shipment.

TABLE CXXIV.

Trees found near the River Zambesi.

No.	Local Names.	Dimensions of Stem.		Remarks.
		Length.	Diameter.	
		Feet.	Inches.	
1	Inhanpasse . .	6	8	
2	Pingue or Pad-preto	6	6	Resembles Lignum vitæ.
3	Mocua	14	8—10	Forked knees. Good quality.
4	Imbila	15—18	12	Flexible, light. Middling do.
5	Murumanhâma .	18	12	Pale red colour, light.
6	Mocunca . . .	15—18	8—10	Grows crooked, heavy.
7	Mocôza	35—45	36—48	Yellow colour, light, wormed. Inferior quality.
8	Mucumite or Sandal-wood .	6—8	8	Brown with light and dark shades of colour, heavy, crooked. Good quality.
9	Pamburo . . .	Shrub		
10	Peam	18	12—20	Red colour, shrinks and warps, heavy.
11	Mussangara . .	12	10	Crooked, heavy, liable to split.
12	Taxa	20	20—28	Yellowish colour, heavy. Gcod quality.
13	Mocundo-cundo .	36	40—60	Yellow colour, light, porous, used for masts, bark yields quinine.
14	Mucorongo . .	18	12	
15	Raiz-de-Pingue or Pao-preto . .	...	...	Roots spreading, heavy, black as ebony.
16	Monangare . .	18	20—28	Resembles rosewood, heavy, crooked, used by wheel-wrights, and for blocks.
17	Mocasso-cassa .	18	20—28	Reddish-brown colour, hard, heavy, used for joiners' work. Good quality.
18	Pao-ferra or Iron-wood	24	8	Red colour, hard, heavy, used for furniture and treenails. Good quality.
19	Pao-ferro or Mais-is-curo . . .	24	8	Dark brown, heavy, resembles Sabicu. Good quality.
20	Pangira	30	26	Brown colour, porous, used in house and ship-building.
21	Pao-fava . . .	22	12	Red colour, light, resembles mahogany. Good quality.
22	Metteral . . .	24	12	Ditto, heavier. Ditto, ditto.
23	Mugunda . . .	40—60	12—24	Yellow colour, straight, light, used in ship-building.
24	Morrunda . . .	15	5—8	Ditto, ditto, ditto.
25	Mouna	15	12	Red colour, straight, moderately heavy. Good quality.
26	Luabo	12	10	Ditto, heavy, ditto.

Mention may also be made of Iroko, a very valuable and handsome building and cabinet wood, with characters like Satin-wood or wavy Maple, and yielded by *Chlorophora excelsa* in Yoruba land, West Africa.*

* Kew Bulletin, 1891, p. 42. For further details concerning African trees, the reader may consult Reports of the Colonial and Indian Exhibition—Report on the Natal Forests, H. G. Fourcade, Maritzburg, 1889, and Report of the Colonial Botanist to the Cape (1866).

CHAPTER XXVI.

NEW ZEALAND TIMBERS.

NEW ZEALAND abounds in valuable timbers, some of which are of first importance in building and construction. Perhaps the Conifers are most valuable, but in addition to them we find the following Dicotyledons.

RATA (*Metrosideros robusta*).

This magnificent tree is found in the denser forests of New Zealand, where it reaches its greatest perfection on a rich soil, and with a moderate degree of moisture. In such situations it very commonly attains the height of 80 to 100 feet, with a circumference of from 9 to 12 feet.

It often rises with a clear stem to 30 and even 40 feet without a branch, and then puts out very ponderous and robust arms, forming a heavy top. The leaves are marginate, and of a light green colour, 1½ inch in length and ½ inch in width. In December and January this tree puts forth very beautiful crimson polyandrous flowers, which render it conspicuous at a considerable distance.*

* There are some very fine creepers growing up the stem and over the tops of the tallest trees in the New Zealand forests, that are so exceedingly like the Rata in wood, bark, leaf, and flower, that I could never distinguish any difference between them. [Some other species of *Metrosideros* are climbers.]

The Rata tree yields timber 12 to 30 inches square, and 20 to 50 feet in length. The bark is ragged in appearance and dark brown in colour; the wood red, hard, heavy, close-grained, strong, and not difficult to work. It is fit for employment in ship-building, and for any work in civil architecture requiring timber of straight growth and large dimensions; the natives assert that it is very durable.

The specific gravity of the Rata, freshly cut, is about 1228, but when seasoned only about 786.

POHUTUKAWA (*Metrosideros tomentosa*)

is found only on the rocky shores and outlets of rivers in New Zealand. It prefers an exposed situation to any other, and requires but little soil for its nourishment.

The bark is ragged in appearance, thick, reddish-grey in colour, and yields a good brown dye. The tree is very hardy, attains moderate dimensions, is crooked, misshapen, and branchy, with not more than 10 to 18 feet in length of clear stem. It has a thick foliage of dark green glossy leaves of about 1½ inch in width by 2 inches in length, and in December puts forth quite a covering of large crimson polyandrous flowers.

The Pohutukawa tree yields timber 9 to 16 inches square, and 10 to 20 feet in length. The wood is red in colour, hard, strong, heavy, and close-grained. In form and quality it is admirably well adapted for the frames of ships, or any other purpose where curved timber is required. The natives speak of it as being very durable.

Specimen logs of this compass timber were brought to England in 1843, and placed in store at Chatham Dockyard, for use experimentally in ship-building, and

in 1869—*i.e.*, twenty-six years later—two or three pieces were still there in a perfectly sound state. The specific gravity of Pohutukawa, green or fresh cut, is about 1200, but after seasoning it is only about 858.

PURIRI (*Vitex litoralis*)

is common to nearly all the forests of New Zealand, and flourishes in almost any situation, but the best trees are those grown on a rich soil, and sheltered from strong winds.

The stems of these trees vary from straight to every imaginable form of curved growth, and are seldom seen standing erect. Usually they have a short clear bole or trunk of from 8 to 18 feet in length, with a circumference of 6 to 9 feet, and an overpowering weight of robust branches. The foliage is a deeply-veined, plain-edged, light green leaf, 2 inches in breadth by 3 inches in length. It flowers nearly all the year round, and is especially full in September; the flowers are of a deep red colour, and somewhat bell-shaped. The fruit, which is like a cherry, is a favourite food of the wood-pigeon.

The Puriri tree yields timber 9 to 18 feet in length, and 10 to 18 inches square. The bark is thin, smooth, and greyish-white in colour. The wood is dark brown, extremely hard, heavy, close-grained, and generally free from defects, the exception being that it is liable to some slight injury during growth from a worm, which bores it from the roots upwards, leaving a clean hole of from ½ to ⅝ths of an inch diameter. The alburnum or sap-wood on this tree is generally from 2 to 3 inches thick, and of a yellowish colour.

This timber is very durable, and suitable for the frames of ships, and also for many other purposes

where hard, short, curved wood is required. Specimen logs were brought to England to be used experimentally in ship-building. The specific gravity of Puriri in a green state is about 1100, and when seasoned it is nearly 1000.

Other New Zealand timbers are:—

The Maire (*Olea Cunninghamii*), a very hard wood used for mill and wheel work; the "Birch"—really a Beech (*Fagus Solandri*)—a durable hard fencing and pile wood, but not fit for marine work; the Rewa-Rewa (*Knightea excelsa*), valuable in cabinet work; the Hinau (*Elæocarpus dentatus*), a small strong timber used for sleepers, railings, &c., in exposed places; the Taraire (*Beilschmiedia Tarairi*), a hard, compact, cabinet wood, and the allied Tawa (*B. Tawa*), similarly useful for furniture work; Mangeas (*Tetranthera calicaris*), used for blocks, &c.; and a number of others.

Part III.—Coniferous Timber Trees.

So far we have been concerned entirely with timbers yielded by Dicotyledons, but there are many valuable timbers derived from the class of Conifers, of which the Pines and Firs are the most important. The principal feature about these woods is their freedom from true vessels, and their consisting of tracheids only; consequently their structure is very uniform, and, since true fibres are absent, on the whole soft and even in texture. It is, in fact, principally due to this uniformity of structure and soft, even texture that Coniferous woods are so valuable; and when, as so often occurs, these woods abound in resinous substances, which aid them in resisting water and other destructive agents, we realise that the great value of Coniferous timbers consists principally in their combining the properties of lightness and softness, which render them easy to work, with a fair amount of durability.

Nevertheless, Coniferous woods differ very much in the degrees in which these valuable properties are combined, not only in the various species, but even in the same timber grown under different conditions.

The following are the more important European species.

CHAPTER XXVII.

PINES.

MANY woods yielded by true Pines are known as Firs in commerce; thus the Scotch Pine is often called Scots Fir, and its timber comes into the market under a most puzzling variety of names—*e.g.*, Red Fir, Yellow Fir, often complicated by names derived from the ports of shipment: Riga, Memel, Dantzic, Stettin, &c., and so on. I retain the ordinary terminology, but it should be remembered that Firs proper are only of the genera *Abies*, *Picea*, *Tsuga*, and *Pseudo-tsuga*. It should further be noted that the various kinds of wood denominated as Dantzic, Memel, Riga, and Swedish Fir (or Pine) are not botanically different species, but merely the timber of the same tree grown and shipped in different districts. Broadly speaking, all the red and yellow timber coming from the Baltic ports goes under the name of Fir, though it is really the wood of a Pine (*P. sylvestris*). White Fir is the Spruce (*Picea excelsa*), commonly known as White Deal.

DANTZIC FIR OR NORTHERN PINE (*Pinus sylvestris*).

The wood of this tree takes its name from the port of shipment, the forests from which it is drawn being spread

over very large districts in Prussia proper, Prussian Poland, and upon the borders of Russia, whence the timber, after being prepared partly in the round and partly in the square state, is floated in large rafts down the River Vistula to Dantzic, advantage being taken of this mode of transit for bringing considerable quantities of corn from the interior to be shipped to foreign markets.

These trees frequently grow to a great height, and throw out numerous branches; they yield the Dantzic Fir of commerce in the shape of rough spars for masts, from small to medium sizes; timber varying from 11 to 20 inches square and from 18 to 45 feet, and occasionally even greater lengths; deals of various thicknesses, from 2 to 5 inches and 18 to 50 feet in length; railway sleepers, &c., &c., which are shipped in large quantities chiefly to this country.

The Dantzic Fir is known locally as Redwood, although its colour is whitish, and only slightly tinged with red. It is even and straight in the grain, tough, elastic, and easily worked, and as it is moderately hard in texture, as well as of light weight (the specific gravity being only about 582), it is used more generally, and in much larger quantities, than any other kind of Fir for building purposes. It is characteristic of it to have a large amount of alburnum or sap-wood, especially upon the small and medium size trees. Very great care is therefore necessary in the conversion of this wood, to ensure the production of the deals and other scantlings of the required dimensions free from sap, the difficulty being often enhanced by the fact that in working on fresh logs, the sap can scarcely be distinguished from the heart-wood, although, if exposed a short time only to the atmosphere, the difference soon becomes visible, the

moisture of the latter drying up more rapidly, and leaving it lighter in colour. The Dantzic converter is, however, by dint of practice, generally so correct in his judgment, that he seldom fails to obtain all that he requires, even from logs which have a very unpromising appearance.

Previous to shipment at Dantzic, the whole of the timber in the rafts is carefully sorted over, and the best of the round wood, *i.e.*, the longest, straightest, and finest pieces, and those most free from knots, are selected for exportation, under the name of "hand-masts," very little being required to be done to them beyond topping them off to the established length, which is proportioned to their diameter. A few trees, perhaps, which are not perfectly fair and straight in their growth, being trimmed or dressed as may be necessary to make them appear so.

"Hand-mast" is a technical term applied by the mast-maker to a round spar, holding at the least 24, and not exceeding 72, inches in circumference. They are measured by the hand of 4 inches, there being also a fixed proportion between the number of hands in the length of the mast and those contained in the circumference, taken at one-third of the length from the butt-end. All the round pieces which measure less than 24 inches in circumference at the base are simply called spars or poles, while those which measure more than 72 inches in circumference are generally dressed to the octagonal or square form, and are then called "inch-masts." These inch-masts, hand-masts, and spars or poles, if straight, and free from large knots and excess of sap, are much esteemed by the mast-makers, and are considered equal, if not superior, to those obtained from Riga.

The first selection from the round wood having been made for the mast-pieces, the remainder undergoes a

further sorting over, to secure the logs most suitable for conversion into deals, and these are always in great request in England, France, Prussia, &c., the respective governments requiring them in large quantities for the decks of their ships of war. There are also the ordinary demands of the private trade, which are sometimes very considerable. To be fit for deck purposes the deals must be of the very best quality, and free from large or defective knots, cup-shake upon the upper or outer surface, and they must also be free from sap.

The round wood logs remaining from these two sortings serve for conversion into plank and board for the home or country trade, and, as in this they are not very particular about the sap-wood being removed, it is all worked up very closely, and with the least possible loss. The coarse and irregularly grown trees, which are brought into Dantzic in a round state, are a special class, and require but little consideration; they pass at once for conversion into railway sleepers, and are exported in large quantities to various parts of the world.

The square timber also undergoes a very careful sorting with the view to its classification under the heads of crown, best, good, and common middling qualities, and sometimes even making a fifth class, if it be short, small, or irregular.* The prices of these several descriptions vary with the quality and average length; and, at the present time (1875) in the London market, they stand at about seventy to ninety shillings per load for best, sixty to eighty shillings per load for good, and fifty-two to fifty-eight shillings per load for common middling. The crown and the fifth class being special distinctions, are, respectively, a little above and a little below these prices.

* There is also a small or undersized class of Memel and Dantzic Fir timber, called Mauerlatten.

There are no reliable or recognised official brands by which the several qualities of Dantzic Fir timber may be known, there being no sworn Bracker to make the sorting; consequently, as each merchant acts for himself, he can give to it any particular distinguishing mark he pleases, and of course this will be only known in his own private circle, or, at most, to the trade of the district. The result is, there are often as many marks for each quality as there are merchants dealing in the article, thus making it necessary to see the several kinds in order to determine which would be most suitable for the work to be done. The practice is not a very satisfactory one, since it is not an uncommon thing to find the best middling timber of one merchant 3 to 4 or 5 per cent. better in quality than that of another, and the same with regard to each of the other classes brought into the market.

Dantzic Fir is employed more extensively in civil architecture than, perhaps, any other description of wood for joists, rafters, trusses, floors, scaffolding, &c.; it also enters largely into the construction of bridges and railway works; indeed, it is not too much to say that few works in this country are ever carried on without its capabilities being in some way turned to account. In ship-building it is employed for beams to carry the upper and lighter decks, occasionally for bottom plankings, and also for various fitments in cabins and store-rooms; and its special fitness for deck purposes has been already mentioned. Further, the cheap, common, middling quality is in request for props, or shores, required for supporting a vessel while in course of construction, or while in dock undergoing repairs, for which, and similar purposes, its coarse character is not an objection.

Having in former chapters, treating of the hard-wood trees, adopted the British Oak timber as the standard of quality and fitness for all the purposes of naval and civil architecture, it is proposed to adopt the Dantzic Fir timber—the most important and generally useful of the Firs and Pines—as the standard of comparison for the soft or white wood class. The author has, therefore, gone more fully into the experiments on this timber than would have been possible with each of the other descriptions.

The transverse experiments recorded in Table CXXV. were made upon pieces of well-seasoned wood, of good average quality, and in every respect fit to be employed in the best architectural works, their specific gravity ranging from 478 to 673, and averaging 582. Of these specimens the elasticity of one piece was perfect immediately after the weight of 390 lbs. was removed, and in each of the others it was very nearly so, the average of the whole giving only ·066 of deflection. All these would probably have recovered their straightness if time had permitted of their being left for only a short period prior to proceeding with the breaking strain.

The strains required to break these specimens varied very much, the minimum being 700 and the maximum 970 lbs., the average 876·6 lbs. on pieces of the standard dimensions. The deflections at the crisis of breaking varied from 4·5 to 6·15 inches, and averaged 5·142 inches.

The experiments for determining the direct cohesive strength are, as before stated, somewhat difficult to carry out, even upon the hard woods, but they are infinitely more so on the soft woods, owing to the liability of the pieces to crush in the clamps holding them before the

true tensile strain could be reached. The results given in Table CXXVI. were, therefore, only obtained after much perseverance and not a few failures. The five pieces subjected to the strain bore respectively 2,240, 2,800, 3,220, 3,416, and 4,480 lbs., giving an average of 3,231 lbs. as the direct cohesion per square inch. Their specific gravities varied from 512 to 639, the average being 603, which is very near the average specific gravity of the pieces tried for the transverse strength.*

A great many experiments were made to ascertain the resistance of this wood to a vertical or crushing force, the details of which are given in Tables CXXVII. to CXXXI. From Table CXXVIII. it may be deduced that the proportion of length to section best adapted for carrying the greatest weights is when the sectional area in inches is to the length in inches as 4 : 5 or $\sqrt{\frac{4}{5}L}$ = side of square for the base. This confirms the opinion before given as regards English Oak; but the rule must rather be considered approximate than absolute, for in the experiments on pieces 3″ × 3″ (Table CXXIX.), the maximum strength lay in that of 12 inches in length, making the proportion as 9 : 12 ($\sqrt{\frac{9}{12}L}$ = sectional area). If, however, the area of the base (or the sectional area) be too small for the length of the pillar, it will be liable to bend or buckle up under the load, showing that stiffness is an important element in the condition of strength.

Specimens were also tested measuring 4″ × 4″ (Table CXXX.), but the results obtained were scarcely so

* The results of nearly all my experiments on the tensile strength of woods are lower than the values given by Rankine, Tredgold, and some others. But as the specimens 2″ × 2″ × 30″ were each tested by hydraulic machinery most carefully applied, the tabular values here given may, I consider, be depended upon.

satisfactory as before, in consequence of the sudden falling off in strength in the 21-inch piece; still there is, perhaps, sufficient to indicate that the maximum of strength would be in a length of about 20", in which case the proportion of base to length would still be as 16:20 or 4:5.

Table CXXXI. shows the result of some vertical tests on pieces 6"× 6" and even larger, but the lengths are not in the same proportion to the scantlings given in former tables, there not being any means at my disposal for holding pieces of greater length than 30 inches. Whether the result would have been the same if this had been possible, cannot therefore be determined by the experiments herein referred to.

TABLE CXXV.—FIR (DANTZIC).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	2·25	·10	5·15	845	534
2	2·00	·05	4·50	700	478
3	1·25	·00	4·65	970	673
4	1·25	·05	5·25	856	512
5	1·75	·10	6·15	944	639
6	1·25	·10	5·15	945	656
Total . .	9·75	·40	30·85	5,260	3492
Average .	1·625	·066	5·142	876·66	582

Nos. 1, 2, and 3 broke with a scarph-like fracture, 10 inches in length; 4 and 5 a little longer and more splintery; 6 about 15 inches, and also sp'intery.

TABLE CXXVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	534	13,664	3,416
8		673	17,920	4,480
9		639	12,880	3,220
10		656	11,200	2,800
11		512	8,960	2,240
Total . .	...	3014	64,624	16,156
Average .	...	603	12,925	3,231

TABLE CXXVII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	3·625	12·875	27·875	47·875
16, 17	2·625	12·750	—	—
18, 19	3·750	12·500	—	—
20, 21	3·250	13·000	—	—
22, 23	3·250	12·125	—	—
24, 25	2·375	12·875	—	—
Total. . .	18·875	76·125	—	—
Average .	3·146	12·687	27·875	47·875
Do. per in.	3·146	3·172	3·097	2·992

TABLE CXXVIII.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
26	1			0 2	756	10·875	2·719
27	2			0 3½	756	12·687	3·172
28	3			0 5	720	11·875	2·969
29	4			0 7	756	13·750	3·437
30	5			0 7¾	669	13·750	3·437
31	6			0 9	648	13·000	3·250
32	7			0 10	617	12·750	3·187
33	8	2 × 2	4	0 11½	621	12·125	3·031
34	9			0 15	720	12·125	3·031
35	10			0 15½	669	12·500	3·125
36	11			1 2½	726	11·625	2·906
37	12			1 5½	774	12·000	3·000
38	18			1 10½	636	11·500	2·875
39	24			2 6	684	10·875	2·719
40	30			2 14	662	10·500	2·625

TABLE CXXIX.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
41	8			1 15	744	21·750	2·417
42	9			1 15½	672	21·500	2·388
43	10			2 1	634	21·625	2·403
44	11			2 4	629	21·500	2·388
45	12	3 × 3	9	2 15	752	21·875	2·431
46	13			2 13½	672	15·250	1·694
47	14			3 4	713	20·250	2·250
48	15			3 5	679	21·250	2·361

TABLE CXXX.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
49	15	4 × 4	16	5 0	576	37·500	2·343
50	15			4 5	497	32·000	2·000
51	16			5 9	600	36·250	2·265
52	16			4 10	500	34·500	2·156
53	17			6 4	635	36·500	2·278
54	17			4 14	496	32·250	2·015
55	18			5 4½	507	37·875	2·368
56	18			5 9½	556	33·500	2·093
57	19			5 7	494	33·875	2·118
58	20			5 14	508	34·500	2·156
59	21			6 2	504	28·000	1·750
60	22			6 6	501	33·900	2·118
61	23			6 10	498	37·700	2·356
62	24			6 11	495	34·400	2·150

TABLE CXXXI.

Vertical Experiments on pieces of various dimensions.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
63	12	6 × 6	36	8 15	571	132·00	3·640
64	18			15 4	654	153·00	4·277
65	24			17 4½	554	153·00	4·277
66	30			24 4	622	122·20	3·394
67	12	9‴ × 10″	102·37	27 0	608	245·40	2·397
68	15			33 13	608	279·20	2·727
69	15	10″ × 10″	110·25	38 12	648	214·80	1·953
70	18			48 6	673	183·80	1·671
71	18	10′ × 10″	107·5	39 8	564	254·40	2·292
72	21			45 13	561	279·20	2·600

Contracts for the supply of Dantzic Fir timber, Fir deck deals, and Oak plank for the royal navy, are made annually, the quantities of each kind varying according to the requirements of the Service.

The following is the specification and conditions under which they are obtained :—

DANTZIC FIR TIMBER.				Loads.		
				£	s.	d.
	Best Middling . . .	At per load . .				
	Good ,, . . .	,, . .				
	Common ,, . . .	,, . .				
	Deck Deals.					
4 Inches	Crown . . .	At per 40-ft. run	of 3 in.			
	Crown Brack .	,,	,,			
3½ ,,	Crown . . .	,,	,,			
	Crown Brack .	,,	,,			
3 ,,	Crown . . .	,,	,,			
	Crown Brack .	,,	,,			
2½ ,,	Crown . . .	,,	,,			
	Crown Brack .	,,	,,			
2 ,,	Crown . . .	,,	,,			
	Crown Brack .	,,	,,			
	Stage Deals.					
2 ,,	. . . .	,,	,,			

DANTZIC OAK PLANKS.			Loads.		
			£	s.	d.
4½ Ins.	Crown	At per load			
	Crown Brack	,,			
4 ,,	Crown	,,			
	Crown Brack	,,			
3½ ,,	Crown	,,			
	Crown Brack	,,			
3 ,,	Crown	,,			
	Crown Brack	,,			
	&c., &c., &c.				

CONDITIONS OF CONTRACT.

1.—*Quality, Specification, &c.*—The Goods to be supplied are to be answerable in every respect to the following Specifications; and to be imported direct from the Baltic.

FIR TIMBER.—The Dantzic Fir Timber to be of the latest felling, free from defective knots and shakes, and to be the best goods obtainable.

In the *Best Middling* quality the spine to be seen from the butt to the top in the greater part of the delivery, and the heart not to be more than one-fourth the breadth from the centre of the log.

In the *Good Middling* quality the spine to be seen for two-thirds of the length in the greater part of the delivery.

The *Mauerlatten* to be of the best quality.

The Best and Good Middling qualities to be 12 inches square and upwards, averaging not less than 13½ inches, and to be 18 feet long and upwards, averaging not less than 24 feet. The whole to consist of a good assortment of lengths and sidings. The Mauerlatten to be 9 to 10 and 10 to 11 inches square in equal proportions.

The quantity required to be delivered in the following proportions of quality, viz., 60 per cent. to be Best Middling quality, 20 per cent. to be Good Middling quality, and the remaining 20 per cent. to be Mauerlatten.

DECK DEALS.—The Dantzic Deals for Decks of 4 inches thick to be cut 8 inches in breadth, and to be 8 inches clear of sap for the greater part of their length, and nowhere less than 7½ inches clear of sap, and to be 26 to 40 feet in length, averaging not less than 33 feet. The Deals of 3½ and 3 inches thick to be cut 8 inches in breadth, and to be 7½ inches clear of sap for the greater part of their length, and nowhere less than 7 inches clear of sap, and to be 25 to 35 feet in length, averaging not less than 30 feet. The Deals of 2½ inches thick to be cut 7½ inches in breadth, and to be 7½ inches clear of sap for the greater part of their length, and nowhere less than 7 inches clear of sap, and to be 25 to 35 feet in length, averaging not less than 30 feet. The deals of 2 inches thick to be cut 7½ inches in breadth, and to be 7½ inches clear of sap for the greater part of their length, and nowhere less than 7 inches clear of sap, and to be 20 to 35 feet in length, averaging not less than 28 feet.

A few of the Deals of each thickness, not exceeding 10 per cent. at the most of the quantity ordered, will be accepted of longer lengths than the maximum specified.

The Deals of each thickness to be delivered at each dockyard in the proportion of not less than 70 per cent. Crown quality, and the remainder Crown Brack quality. The whole to be bright, clean, sound yellow wood, converted in the country, and thoroughly air dried before shipment, of an equal thickness and square edged, and to be clear of unsound sap, shakes, injurious knots, and defects, according to their respective brands.

STAGE DEALS.—The Dantzic Deals for stages to be 2 inches thick, 12 to 15 inches in breadth, and 25 feet and upwards in length, averaging not less than 30 feet; the sap on the two edges not to exceed one-half of the breadth. The

whole to be bright, clean, sound yellow wood, converted in the country, of an equal thickness and square edged, and to be clear of shakes, injurious knots and defects.

OAK.—The Dantzic Oak Timber to be the best goods obtainable. The Thickstuff and Planks to be 24 feet long and upwards, averaging not less than 30 feet, and to be 10 inches and upwards in breadth, averaging not less than 11 inches clear of sap; the breadth for measurement to be taken clear of sap at the middle of the length. The whole to be fresh, clean, free from defective wanes, according to their respective brands, cut regular, square edged, and mostly straight, the curve, if any, not to exceed ¾ inch in 6 feet. Not less than 67 per cent. of each thickness to be of Crown quality, and the remainder of Crown Brack quality.

The brand of the respective qualities to be marked upon each description of Timber, Plank, and Deals, and to be stated by the contractors prior to commencing delivery.

2.—The goods are inspected and measured at Dantzic.

3.—*Quantities to be shipped.*—The quantities of goods shipped under this contract must approximate as closely as possible to the respective quantities for each dockyard. Slight variations will be permitted to meet difficulties in procuring the exact tonnage required, but overhead the total quantity of each description must not be exceeded.

4.—*Charters of Vessels to be advised.*—The names of ships chartered in fulfilment of this contract, and in due course the quantities actually shipped, must be advised to the Director of Navy Contracts.

5.—*Delivery.*—Goods delivered by ship or barge are to be put over the side or out of the ports by the crew either into the water or into lighters, as may be directed by the officers.

The officers may also direct the ship or barge to come alongside a quay. In his case, if a crane be available, the goods will be slung by the crew, and will be hoisted out by yard labour. If no crane be available, the goods are to be delivered by ship or barge into the water or on the quay, as directed by the yard officers.

No charge will be made for the yard cranes in performing the services above specified.

6.—*Payment for Supplies.*—With every delivery of goods under this agreement, invoices,* in duplicate, are to be sent to the consignee by the contractors. The duplicate will be returned by the consignee, with the quantities received noted thereon. The contractors are then to send their claim* for payment to the Accountant-General of the Navy, Admiralty, Spring Gardens, London, S.W., by whom an order for payment of the amount due will be forwarded to the contractors.

7.—*Members of Parliament.*—In pursuance of Act 22 Geo. III., Cap. XLV., no Member of the House of Commons is to be admitted to any share or part in the contract, or to any benefit to arise therefrom.

* Forms may be obtained on application to the Accountant-General of the Navy, Admiralty, Spring Gardens, London, S.W.

We occasionally obtain from Dantzic some Fir timber, which is known in the London market under the names of Eliasberg and Saldowitz, from the districts in Russia whence it is drawn.

It is a very clean, sound, straight, and well-squared wood, of great average length, and more closely resembles the Riga Fir than any other in colour, texture, general appearance, and even in its defects, the heart and star-shakes being common to it. This wood cannot, therefore, be safely reduced to thin planks near the centre of the log without incurring the risk of some faulty pieces being produced at that part.

The classification for the market is similar to that of the Dantzic Fir, but there is very little of the common middling quality in it. When made up for sale it is generally arranged in parcels according to the size of the logs, those of 13 to 16 inches being kept distinct from those over 16 to 20 inches square, the latter being about the maximum size obtainable from the tree, while the lengths vary from 20 to 76 feet, and include many pieces of mast dimensions.

The employment of this description of Fir for mast purposes does not, however, appear to be contemplated by the shippers, and it is not, in my opinion, suitable for it, owing to its free character and liability to split in seasoning. The clean, straight, and even grain is, nevertheless, quite sufficient to recommend it to notice for furniture purposes, and its superior dimensions will always entitle it to preference over Dantzic or Riga Fir for works requiring long timber.

The prices of "Eliasberg" and "Saldowitz" Fir timber in general rule somewhat higher than that of the best Dantzic Fir.

There is also an inferior species of Fir brought in

small quantities from Dantzic, and put upon the market under the name of Whitewood. It is white in colour, soft in character, and generally a little spongy near the centre.

It has a dull shade, and appears to be poor in quality, but, being a light, clean, straight-grained wood, and easy to work, it is suitable for packing-cases and for any ordinary purpose; it thus saves the more expensive kinds of Fir. It is brought to this country in well-squared logs of rather superior dimensions to the Dantzic Fir.

CHAPTER XXVIII.

NORTHERN PINE—(*Continued*).

RIGA FIR (*Pinus sylvestris*).

THIS timber takes its name from the port of shipment, although many of the forests from which it is drawn are very far back in the interior of Russia.* It is the produce of a tree of almost perfectly straight growth, with lighter branches than are usually found in the Firs of the same species brought into Dantzic; it is consequently more free from injurious and objectionable knots.

The Riga closely resembles the Dantzic Fir timber in being whitish in colour and tinged slightly with red, but is rather lighter looking. It is tough, flexible, moderately strong, and scarcely so heavy as the Dantzic Fir, the respective specific gravities being about 541 and 582. It has a clean, fine, straight grain, and is a little shaky at the pith. It cannot, therefore, be converted into

* Slowly grown Pines, such as are found in high latitudes or at great elevations, are usually heavier, denser, and more even in quality than those of the same species in warmer situations; this is because the quantity of softer spring-wood is proportionally smaller in the narrower annual rings. The converse is true of Oak (see Marshall Ward, "The Oak," p. 144. Kegan Paul, 1892).

plank and board so profitably as the Dantzic and some other Firs. With this exception it is a very valuable wood, and is in great request for architectural works of every description; indeed, we find it used for nearly every purpose where light materials are required.

After the felling of this timber, it passes through the process of selecting and sorting over, the same as prevails in the Polish and Prussian forests and shipping ports, with a view to bring out the best pieces for masts, and the coarsest for railway sleepers. The logs of the intermediate class, when hewn into squares, yield dimensions of about 11 to 14 inches on the side, and from 20 to 45 feet in length. This timber is seldom classified as best, good, or common middling, but is placed upon the market unsorted, and without any particular distinguishing brand upon it.

The selected spars generally come to us in a round state, under the name of Hand-masts. These are classed by the brackers at Riga alphabetically A to N, according to their size, the smallest being A, or 6 hands; that is to say, it measures six hands of 4 inches each, or 24 inches in circumference, taken at 4 feet in length from the butt-end of the spar: the largest being N, or 18 hands, or 72 inches in circumference. The lengths of these two sizes are respectively 36 and 74 feet. The following very plain rule prevails by which the established length to the number of hands is calculated, viz., rough spars for masts, of 6 to 9½ hands, the number of hands multiplied by 3, and 18 added, gives the length in feet; and spars of 10 to 18 hands, multiplied by 3, and 20 added, gives the length in feet; there being a small proportional increase of length required for vessels carrying the larger sizes.

The straightest and best spars have simply the bark taken off them, and the knots dressed smoothly, with perhaps a few feet in length at the butt-end hewn, to remove the swelling which often occurs at the base of the tree. Beyond this, owing to their generally fair and even growth, very little is required, and, as the alburnum or sap upon this description of timber is not usually more than about 1 inch in thickness, the waste sustained in their conversion into masts is altogether insignificant. These Riga spars (their generally small and medium sizes being considered) are about the best to be met with, and are in great favour with the mast-makers of the royal dockyards, though somewhat less so in the private trade.

There are, besides the hand-masts, many straight and fair-grown trees that measure less than 24 inches in circumference at the base, which are simply termed spars, or poles. There are also a few pieces occasionally met with that exceed the maximum size of the hand-mast, which are generally dressed approximately to an octagonal form, and then, as at Dantzic and elsewhere, they are called inch masts.

In ordinary specifications for building, it is stipulated the Fir is to be from Dantzic or Riga, as if they were equal in quality; but my experiments on Riga Fir, though not nearly so numerous as those on Dantzic, prove the former to be slightly inferior to the latter. The tables on the following and preceding pages show that the strength of the Riga is to that of Dantzic Fir as follows, viz.:—

Transversely	as	150	:	219	or, it is	weaker	by about	31	per cent.
Tensilely	,,	4051	:	3231	,, ,,	stronger	,,	20	,,
Vertically	,,	5247	:	6948	,, ,,	weaker	,,	24	,,

TABLE CXXXII.—FIR (RIGA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·10	3·00	580	524
2	1·00	·10	3·75	707	584
3	1·50	·10	3·30	498	518
4	1·50	·05	4·50	615	534
5	1·35	·10	3·85	677	570
6	1·15	·10	3·35	523	516
Total . .	7·75	·55	21·75	3,600	3246
Average .	1·292	·092	3·625	600	541

REMARKS.—No. [illegible] broke a little short 2 and 3 with fractures 9 inches in length; i
4, 5, and 6 the fractures were longer and splintery.

TABLE CXXXIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	584	17,920	4,480
8		524	12,320	3,080
9		570	19,600	4,900
10		534	14,980	3,745
Total . .	...	...	64,820	16,205
Average .	...	...	16,205	4,051

TABLE CXXXIV.

Vertical or Crushing Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	3·250	9·000	16·	34·875
15, 16	3·125	7·875	—	—
17, 18	3·500	8·250	—	—
19, 20	3·750	8·500	—	—
21, 22	3·250	8·750	—	—
23, 24	3·000	8·250	—	—
Total . .	19·875	50·625	—	—
Average .	3·312	8·437	16·	34·875
Do. per in.	3·312	2·109	1·77	2·179

The Riga is of slower growth than the Dantzic Fir, the difference being about 0·4 layers per inch in diameter (*vide* Table I.); this, in view of the theory previously set up, indicates that it is inferior to the Dantzic Fir.*

Contracts for the supply of Riga Fir timber, and hand-masts for the royal navy, are made annually; the quantities of each kind varying according to the requirements of the several dockyards. They are received under the following specification and conditions, viz., the timber at per load of 50 cubic feet, and the hand-masts at each.

* See footnote, p. 329.

TABLE CXXXV.

Vertical or Crushing Experiments.

Number of the specimen.	Length of the specimen.	Scantling.	Area in square inches.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on 1 square inch.
	Inches.	Inches.		lbs. ozs.		Tons.	Tons.
25	1	2 x 2	4	0 1	...	9·875	2·469
26	2	2 x 2	4	0 2	...	8·437	2·109
27	3	2 x 2	4	0 3½	...	11·500	2·875
28	4	2 x 2	4	0 4½	...	9·000	2·250
29	5	2 x 2	4	0 7	...	10·500	2·625
30	6	2 x 2	4	0 8½	...	11·250	2·812
31	7	2 x 2	4	0 10	...	11·125	2·781
32	8	2 x 2	4	0 10½	...	11·000	2·750
33	9	2 x 2	4	0 12	...	10·000	2·500
34	10	2 x 2	4	0 15	...	8·000	2·000
35	11	2 x 2	4	1 1	...	9·750	2·437
36	12	2 x 2	4	1 3	...	11·125	2·781
37	18	2 x 2	4	1 6	...	9·875	2·469
38	24	2 x 2	4	1 8½	...	6·875	1·719
39	30	2 x 2	4	2 5½	...	7·375	1·844
40	12	9½ x 10½	100	28 1	647	367·80	3·678
41	15	9½ x 10½	100	27 7	506	214·70	2·147
42	18	9½ x 10½	100	33 0	507	245·40	2·454
43	21	9½ x 10½	100	48 3	634	245·40	2·454
44	18	10½ x 10½	110·25	46 6	646	307·00	2·784
45	21	10½ x 10½	110·25	54 11	654	307·00	2·784
46	24	10½ x 10½	110·25	55 4	577	279·20	2·532
47	27	12 x 12	144	85 0	604	378·72	2·630
48	30	12 x 12	144	92 6	593	396·28	2·752

CONDITIONS OF CONTRACT.

All the goods supplied under this contract to be imported direct from the Baltic; to be of the best quality, fresh cut, good, sound, merchantable, and well conditioned.

The Riga Fir timber to be 11 inches square and upwards, averaging at least 12 inches, meeting in length at 24 feet, and none to be shorter than 18 feet the longest timber to be of the greatest scantling, and the spine to be seen from the butt to the top on each of the four sides.

The Riga hand-masts to be of the dimensions specified, straight grown, and free from heart-shake and injurious knots. One-third of all the masts of 9 hands and under to be 4 feet longer than the prescribed length.

TABLE CXXXVI.

SPECIFICATION FOR HAND-MASTS (RIGA*).

—	Hands.	Length.		Diameter.	Distance from butt, 8″ to a hand.		Diameter.	Distance from top, 4″ to a yard.	
		Ft.	in.	Inches.	Ft.	in.	Inches.	Ft.	in.
N	18	74	0	22⅞	12	0	15¾	8	2
M	17½	72	6	22¼	11	8	14⅝	8	0
	17	71	0	21⅝	11	4	14¼	7	10
L	16½	69	6	21	11	0	14	7	8
	16	68	0	20⅜	10	8	13½	7	6
K	15½	66	6	19¾	10	4	13¼	7	4
	15	65	0	19⅛	10	0	12¾	7	2
I	14½	63	6	18½	9	8	12⅜	7	0
	14	62	0	17⅞	9	4	11⅞	6	10
H	13½	60	6	17¼	9	0	11½	6	8
	13	59	0	16½	8	8	11	6	6
G	12½	57	6	15⅞	8	4	10¾	6	4
	12	56	0	15¼	8	0	10⅛	6	2
F	11½	54	6	14⅝	7	8	9¾	6	0
	11	53	0	14	7	4	9⅜	5	10
E	10½	51	6	13⅜	7	0	8⅞	5	8
	10	50	0	12¾	6	8	8½	5	6
D	9½	46	6	12⅛	6	4	8	5	2
	9	45	0	11⅜	6	0	7⅝	5	0
C	8½	43	6	10⅜	5	8	7¼	4	10
	8	42	0	10⅛	5	4	6¾	4	8
B	7½	40	6	9½	5	0	6⅜	4	6
	7	39	0	8⅞	4	8	5⅞	4	4
A	6½	37	6	8¼	4	4	5½	4	2
	6	36	0	7⅝	4	0	5	4	0

* The above Specification will serve, with a slight modification of the hands to the length, for Dantzic Fir, Canada Red Pine, and also for Virginia Pitch Pine, due regard being paid to the difference in the quantity of sap-wood on each compared with Riga Fir. Hand-masts are frequently sold in the private trade at per load.

CHAPTER XXIX.

NORTHERN PINE—(*Continued*).

SWEDISH FIR (*Pinus sylvestris*)

IS, as its name indicates, a native of Sweden, where it is very abundant, and attains, under favourable circumstances, a height of from 50 to 80 feet, with a circumference of from 4 to 5 feet; it yields timber in logs of 20 to 35 feet in length by 10 to 16 inches square. From the smaller trees, deals 3 inches thick, by 7 to 9 inches broad, and 12 feet and upwards in length, are obtained.

The wood is of a yellowish-white colour, soft, clear and straight in the grain, with only small knots, and very little alburnum or sap-wood on it. Of late it has been in great request for common building purposes, as it is considerably cheaper than Dantzic or Riga Fir timber.

Swedish Fir is liable to the heart and star-shakes, and not unfrequently the cup-shake. On this account it is not suitable for conversion into board for joiners' work, but only for the rougher and more ordinary works in building operations. This species of Fir is of very slow growth, and, during the early stage of its existence, it makes wood at only about

half the rate of the Dantzic, Riga, and Polish Firs, but gains slightly upon this rate as it approaches maturity.

In consideration of the defects mentioned, there is little to recommend the Swedish Fir to favourable notice, beyond the fact of its being cheap and suitable for the coarser purposes in carpentry.

About 3,500,000 Swedish deals, 7,000 loads of timber, and 18,000 fathoms of firewood, were imported into London in 1874, besides a large quantity of boards for flooring, &c., &c.

NORWAY FIR

is of straight growth and small dimensions, and balks of about 8 or 9 inches square only are produced from it, but even these are not now shipped in any considerable quantity for the English market.

The Norwegians appear to find it most advantageous to convert their Fir timber (which is generally of a coarse description and inferior in quality) into battens of 6 to 7 inches in breadth, by less than 3 inches in thickness, and into prepared flooring and match-boards, which are sold by the "square" of 100 superficial feet of 1 inch thick. They also produce a few deals of 3 x 9 inches, varying in length, for exportation; and, as the whole of these are manufactured and sold at a very cheap rate, they pass readily into consumption for the building of the lowest and poorest class of houses.

Norway supplies, in addition to the timber, deals, and battens, considerable quantities of small spars, and Fir for firewood, to the London market.

CHAPTER XXX.

COMMON OR NORWAY SPRUCE OR "WHITE FIR" (*Picea excelsa*)

IS very abundant upon the mountain slopes in Norway, and throughout Europe down to the Alps, and prefers generally a damp climate and moist soil to bring it to the greatest perfection. In such situations, it frequently reaches to a height of 80 to 130 feet, with a circumference of 3 to 5 feet. It may also be found upon most of the mountainous parts of the North of Europe, and is abundant in North America. The Spruce Fir is an evergreen, and assumes in open ground a beautiful pyramidal form, with the lower branches drooping nearly to the ground; the leaves are solitary and very short, and the cones long and pendulous, with the scales thin at the edges. It will thus be easily distinguished from the Pines, which have their leaves clustered in twos or threes, and cones of quite different characters.

The wood, which is commonly known as White Deal,*

* Deal is a word with regard to which the reader may be put on his guard, as it is often loosely applied to very different timbers. White deal is the wood of the Norway Spruce (*Picea excelsa*). Yellow deal is the wood of the Norway Pine (*Pinus sylvestris*), but it is often called Red deal. Strictly speaking, the word deal refers to these woods cut to particular sizes, &c., and not to the timber itself.

is white in colour, straight and even in the grain, tough, light, elastic, and more difficult to work than Pine, owing chiefly to the excessive hardness of the small knots which are frequently found in it. When cut into deals it is somewhat disposed to warp, unless carefully weighted in the stacks or piles during the process of seasoning. The shrinkage is inconsiderable, and the sap, though generally only of moderate thickness, varies from half an inch, in some trees, to 2 or 3 inches in others.

The Spruce Firs are not suitable for the best-finished carpenters' or joiners' work, but for framing and the coarser descriptions of work it may be used with advantage, and also in ships for any of the fitments in store-rooms, for lockers, shelves, mess-tables, &c.

The trees are generally straight, and being strong as well as elastic, they are admirably suited for making the small spars required for ships and boats. They are also in great request for ladders and scaffold poles, and for stage-making in ship-yards.

Norway spars are known under the following designations, and are classified for the navy contracts according to their size, thus:—

TABLE CXXXVII.

SPECIFICATION.

No.	Description.	Length.	Diameter.	From the butt.	Diameter.	From the top.
		Feet.	Inches.	Ft. in.	Inches.	Ft. in.
5	Cants	34 to 36	7 to 6½	at 3 4	3¾	at 3 8
4	Barlings ...	31 ,, 33	6 ,, 5½	2 8	3	3 4
3	Booms......	28 ,, 30	5 ,, 4½	2 0	2¼	3 0
2	Middlings.	23 ,, 26	4 ,, 3½	1 4	1¼	2 8
1	Smalls......	19 ,, 22	3 ,, 2	0 8	1	2 4
...	Poles	21 ,, 42	5	...	...	...

These spars are usually bought for the navy at a price each, but for the private trade they are not unfrequently sold at per foot run.

Nothing is done to these trees after they are felled, beyond removing the small branches, cutting off the top, and making the ends even, to prepare them for the market. They are, therefore, brought to us with the bark on, and are measured over all. It is well, however, to take the bark off if they are not required for immediate use, otherwise they will suffer injury from the attack of a small worm which after a few months appears between the bark and the alburnum.

The Spruce Fir has a further intrinsic value in yielding a resinous fluid which constitutes the foundation for the manufacture of pitch. The Spruce Firs are all of very slow growth, and not so durable as Pine.

The trade in foreign deals, battens, boards, &c., from the countries in the North of Europe, is very great, and there were imported into the United Kingdom, in 1874, 2,800,000 loads; in 1873, 2,450,000 loads; in 1872, about 2,300,000 loads; as compared with 2,140,000 loads in 1871; 1,900,000 loads in 1870, and 1,380,000 loads in 1866. Large as these quantities are, they seem likely to go on increasing, and will probably continue to do so, until the supply is exhausted. Sweden has contributed the larger portion of these, Norway and Russia come next, and are nearly alike in quantity; Prussia follows, and Finland supplies least of all.

To particularise and describe the various shades of difference to be found in the quality of these deals, battens, &c., would be next to impossible, drawn as they are from so many ports of shipment in each of the

countries referred to; but, taking them in a general way, the order of quality would stand, first or best with Prussia, then with Russia, Sweden, and Finland, and lastly, with Norway. Each of these countries classify their goods by first and second, and sometimes third quality, the respective distinctions of classes being based upon the perfection or otherwise of the manufacture, and freedom from shakes, sap, or defects.

From whatever source these deals are obtained, they are usually branded with some fancy mark, letter or device, as varied in character as the names of the different merchants who produce them. These trade-marks are all liable to be changed, and the purchaser, unless he can make the selection for himself, must rely upon the reputation and integrity of the firm he treats with, for obtaining the particular article he may require.

The following are samples of the trade-marks in present use upon deals and battens :—

TABLE CXXXVIII.

Where from.	First Quality.	Second Quality.	Third Quality.
Christiania	H+G; H✱M; AOH; AHO; A+T; GAH.	HMH; AHA; A+H; HSG; V+V; LM.	H+H; T+I; T+B; B+K; L+B.
Dram	T+H; HK; O+H; E+T; HB.	N+N; KW; TH; DD; OO; B; T✱H; SH; C&Co; T; OH; SK; E+T; E✱T.	IW; C; BB; H; B; K; HH; TT; H+H.
Fredrikstad	FAA; TWS; H+B; H✱B; JNJ; W+G; W♛G; W♛♛♛G.	A+F; S—bak; HHH; W+W; MM; TS.	HBT; SS; MMM.
Fredrikshald	SFA.	SFB.	FSC.
Gefle	C♛B; A♛S; G♛H; M♛S; EAB; KAB; KHB; SKB; GH+A.	The same marks as first quality; colours may vary.	NAS; C+B; A+S; BL; DOM; FAB; HAB; G+H; B+B; GH+B.
Hernosand	S♛W; H♛A; WAYA; J♛N; HC.	Ditto, ditto. Ditto, ditto.	S+W; M♛S; N+N; H✱A; W&Co.
Hudikswall	HC; H♛H.	H+H; H✱H; H.	PP; FB; HHH.
Husum	DB&Co.	DB&Co.	DDD.
Lulea	GM.	GH.	GT.
Sundswall	H♛H; A♛A; A♛B; E✱A; N+W.	The same marks as first quality; colours may vary.	A✱A; A✱B; E+A; ALB; NW; NAS.

SILVER FIR (*Abies pectinata*).

The only other European Fir of commercial importance is the Silver Fir, belonging to a genus (*Abies*) differing from the last chiefly in that the cones are erect, and do not fall as a whole when ripe, but shed their scales.

The pinkish white and scarcely resinous wood works up well, with a bright silky lustre, is of excellent quality for carpentry and ship-work. It is light and stiff, and, like Spruce, takes glue well. Nevertheless it is as yet far less in request than the latter, though it is employed in the making of paper pulp as well as for boards, rafters, &c.

CHAPTER XXXI.

EUROPEAN CONIFERS—(*Continued*).

LARCHES.

LARCH (*Larix Europæa*).

THIS is a deciduous tree, and is distinguished by botanists from the Pines, Firs, and Cedars on account of its deciduous leaves and other characters. The leaves grow in clusters and spread out in a brush or mop-like form, and in the spring, when quite fresh, they have a beautiful light-green tint, which make them very remarkable among other trees. The cones are of an oblong shape, and somewhat blunt.

The Larch is a native of the European Alps and the Apennines, and is found abundantly in Russia and in Siberia. It thrives in elevated and comparatively poor land, and is perhaps the most profitable tree that can be planted in an open, dry, moderately fresh soil, if the climate is suitable. It grows at about the same rate, in such situations, as the *Pinus sylvestris* does in more fertile localities, making one inch of wood in about 5½ years, or two feet in diameter in about 130 years (*vide* Table I., p. 45).

In Scotland it has been planted by the Duke of Athol and others in immense quantities, and it has been

stated that at elevations of upwards of 1,500 feet above the sea level, trees have been felled when only eighty years old that have yielded each from five to six loads of timber, while in less elevated positions the produce is said to have been even more satisfactory.*

The wood is of a yellowish-white colour, tough, strong, and occasionally a little coarse, but is generally straight and even in the grain. It works up tolerably well, and is considered to be very durable, but has the serious drawback of excessive shrinkage, with a tendency to warp in seasoning.

The Larch tree yields the Venice turpentine of commerce, which is procured in abundance from the trunks of old trees; the bark also is of considerable value to the tanner. The Siberians make use of the inner bark, mixed with rye-flour, for preparing a sort of leaven, whenever the ordinary supply of the better article fails them.

The Italian Larch timber, some time since imported into this country, was only of moderate dimensions, a little curved at the butt or root end, and straight from about the mid-length, tapering rather quickly towards the top. This timber was generally free from heart-shake, and very solid about the pith, clean and even in the grain over the lower part, but coarse and knotty higher up; consequently, though not well adapted for the ordinary works in carpentry, it was very suitable for

* To test the durability of the Scotch Larch, H.M.'s ship *Athol* was built of this timber in 1820, and about the same time the *Nieman*, also a ship of war, was built of Baltic Fir (*i.e.*, Scotch Pine). The former lasted for a long time without any extensive repairs, but the other decayed very rapidly, and from this comparison the superiority of the Scotch Larch over Fir, for durability, was considered to be pretty well established.

those parts of the frames of ships in which a light material is considered desirable.

It is stated on good authority that the greater number of the houses in Venice are built upon piles of this timber, particularly those of which the supports are alternately exposed to wet and dry; many of these piles, after being in place for ages, are said not to have the least appearance of decay.

This wood evidently stood in high favour in early times. Julius Cæsar—who called it "Lignum igni impenetrabile," because he could not burn it with the same facility as other timber—used it for every purpose whenever he could obtain it. Tiberius Cæsar brought it over long distances from the forests of Rhætia for the reparation of several bridges, and Pliny relates that a Larch tree, measuring 120 feet long and 2 feet in thickness, from end to end, was intended to be used in one of these. It was, however, preserved for a long time as a curiosity, and ultimately employed in the building of a large amphitheatre.

The Polish Larch tree is generally of straight growth, and of dimensions rather exceeding the Italian variety. It is also coarser in the grain, more knotty, and has a larger amount of alburnum, or sap-wood.

The Russian Larch tree attains dimensions superior to either of the foregoing descriptions. A cargo of this timber, very long and straight, was imported into this country a few years since from the district of the Petchora, a river flowing from the Ural Mountains into the Arctic Ocean.

It has been employed experimentally in shipbuilding in Woolwich Dockyard, for deck and planking

purposes (for which it was judged to be especially suitable), in place of Baltic Fir and Pine timber.

It disappointed, however, the expectations of the officers, as it was soon found to shrink so excessively, that it was impossible to keep it weather or water-tight; in consequence of this it was removed from the ship. The remains of the parcel therefore passed into conversion for the most common and ordinary services, and, of the board produced, much was used for berthing in the timber sheds. It stood the test of exposure in such situations for fully eight years without showing any signs of decay, but exhibited a disposition to warp and shrink far exceeding that of any other wood in present use in carpentry.

The subjoined Table, No. CXXXIX., shows that the Russian Larch is slightly deficient in transverse strength, as compared with the Firs and Pines; but, otherwise, it is above their average.

TABLE CXXXIX.—LARCH (RUSSIAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·15	4·5	743	688
2	1·5	·15	5·0	714	697
3	1·5	·00	4·75	708	645
4	1·75	·25	3·85	504	618
5	1·75	·15	4·15	568	647
6	1·65	·35	3·75	519	583
Total . .	9·40	1·05	26·00	3,756	3878
Average .	1·566	·175	4·33	626	646·3

REMARKS.—All broke with a moderate length of fracture.

TABLE CXL.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	618	14,000	3,500
8		645	13,440	3,360
9		647	19,936	4,984
10		688	19,880	4,970
Total . .	...	2598	67,256	16,814
Average .	...	649	16,814	4,203

TABLE CXLI.

Vertical Experiments on Cubes of

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	2·875	10·750	19·625	42·75
15—18	2·750	10·875	19·500	42·50
19, 20	2·875	10·750	—	—
21, 22	3·000	10·375	—	—
Total . .	11·5	42·75	39·125	85·25
Average .	2·875	10·687	19·562	42·62
Do. per in.	2·875	2·672	2·174	2·663

OTHER EUROPEAN CONIFERS.

Apart from the Yew and the Juniper, the wood of which has practically no commercial importance, we have no other Conifers indigenous to Britain except the Scotch Pine. On the Continent, however, the following Pines are noteworthy :—

The Austrian, or Black Pine (*Pinus Austriaca*), a variety of *Pinus Laricio*, extensively grown in the East of Europe, yields a soft wood practically indistinguishable from that of the Scotch Pine, and useful for the same purposes. Other varieties of the same species are the Corsican Pine, the Pyrenean Pine, and some others.

The Cluster Pine (*P. Pinaster*), characteristic of some of the rocky parts of Europe, and much used in the south and west of France, where it is known as the Maritime Pine from the extensive planting on the coasts, yields a highly resinous reddish wood employed in naval work and in carpentry.

The Italian Stone Pine (*P. Pinea*), an allied species, yields a very similar timber, but less resinous and more easily worked in carpentry. The woods of all these Pines are much used on the Continent also for packing-cases and for fuel.

The light, white wood of the Cembran Pine (*P. Cembra*) of the Savoy, &c., is of very little use, and is scarcely employed; and the Mountain Pine (*P. Pumilio*) is more interesting from a forester's point of view than as a timber tree.

CHAPTER XXXII.

AMERICAN PINES.

RED PINE (*Pinus resinosa*).

OF the thirty or more species of *Pinus* of Canada and the United States, several are of importance as timber. One of the best known of these is the Red Pine of Canada.*

In an official report, published in Boston in 1846, on the trees growing naturally in the forests of Massachusetts, it is stated that "The bark of this tree is much less rough than that of the Pitch Pine, and consists of rather broad scales of a reddish colour. The long leaves are in twos, and the cones are free from the bristling, rigid, sharp points which distinguish those of the Pitch Pine. It may also be distinguished at a distance by the greater size and length of the terminal brushes of leaves. It is known in New England by the name of Norway Pine, although it is entirely different from the tree so called in Europe, which is a kind of Spruce; it is known in Canada as Red Pine."

This description of timber, unlike the Dantzic and Riga Firs, which take their title from the port of ship-

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* Sometimes spoken of as "Yellow Pine," but a totally different tree from *Pinus Strobus*. It is also referred to as "Norway Pine" in Canada, but it has nothing to do with *Pinus sylvestris*.

ment, derives its name from the reddish colour of its bark.

It is a native of the United States and Canada, in North America, where it attains a height of from 70 to 100 feet, with a circumference of from 4 to 5 feet. It is more slender than the Pitch Pine, and yields the timber of commerce in logs of from 10 to 18 inches square, and from 16 to 50 feet in length. The tree is of erect growth, with a tendency to slight curvature at the butt or root end of the stem, and, like most other Pines and Firs, has numerous though not usually heavy branches.

The wood is white, tinged with yellow or straw colour; it is tough, elastic, moderately strong, and possesses a clean fine grain, which works up well, leaving upon the surface a smooth silky lustre. It is not apt to shrink, split, or warp much in seasoning, and, technically speaking, it stands well, which renders it a choice and very valuable wood for all kinds of construction, while in the domestic arts there need not be any limit to its application.

The Red Pine is very solid about the pith or centre of the log, and has but little alburnum or sap-wood. There is, therefore, only a small amount of loss in its conversion, even if reduced to planks and boards; while it can further be worked with great advantage in ship-building, for deck purposes, for cabin, and for other fitments.

With every season's fall of this timber there are a few rough spars selected for hand-masts, holding about the same dimensions as those obtained from Riga. These spars, however, are very few in proportion to the number of trees felled, owing to the fact before mentioned, that the trees are not generally quite straight,

although fairly grown. On this account the selected spars nearly all require to be dressed to a straight form, and simply taking off the knotty tops of the trees and removing the bark is not sufficient to constitute the hand-mast of this species of Pine.

The surveyor and mast-maker will, therefore, find it necessary to examine these spars very carefully to ascertain the amount of dressing to which they have been subjected, and whether or not the fibre has been cut or destroyed to a degree that would impair its trust-

FIG. 28*a*.

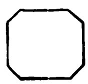

FIG. 28*b*.

worthiness for mast purposes. If the spar is found to be straight and free from injurious knots, and excessive dressing, it may be accepted as likely to do good service, the strength and elasticity of this wood comparing favourably with those of the Riga and Dantzic Firs.

The trees that remain after the spars are withdrawn are hewn into a square form, and have a small amount of wane left upon each angle (Fig. 28). They are also dressed to follow the natural taper of the tree, which is rather more rapid and noticeable than in other Pines.

No particular classification is made of this wood for the market, beyond the separation of the larger from the smaller or building scantlings, and the quotations of prices for the timber are generally for "large," or for "mixed," and "building" sizes.

The Red Pine of Canada is dearer than the Fir timber of the North of Europe by at least the difference in the cost of freight, and, hence, it does not find quite so ready a sale, the quality of the article to be employed in ordinary building operations not being so much a consideration as the quantity to be obtained for money.

TABLE CXLII.—RED PINE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·85	·15	4·50	590	536
2	1·75	·15	4·25	572	525
3	1·50	·10	3·25	588	576
4	1·65	·15	5·75	700	578
5	1·50	·10	5·50	724	552
6	1·75	·15	4·50	746	554
Total. .	10·00	·80	27·75	3,920	3321
Average.	1·666	·133	4·625	653·33	553·5

REMARKS.—Nos. 1 2, and 6 broke with a moderate length of fracture; 3, 4, and 5, rather short.

TABLE CXLIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	536	11,200	2,800
8		525	11,200	2,800
9		552	11,200	2,800
10		554	6,832	1,708
11		578	13,300	3,325
12		576	11,200	2,800
Total . .	...	3321	64,932	16,233
Average .	...	553	10,822	2,705

TABLE CXLIV.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	2·375	8·000	21·875	34·00
17, 18	3·500	8·500	—	—
19, 20	3·250	8·250	—	—
21, 22	3·500	8·750	—	—
23, 24	3·750	8·375	—	—
25, 26	3·500	8·875	—	—
Total . .	19·875	50·75	—	—
Average .	3·312	8·46	21·875	34·00
Do. per in.	3·312	2·115	2·431	2·125

NOS. 27 TO 30.—Four pieces, each 2 × 2 inches, and respectively 1, 2, 3, and 4 inches in length, crushed with 9·375, 8·460, 8·250, and 9·50 Tons.

Contracts are annually made for the supply of Canada Red Pine timber for the royal navy, according to the following specification and condition, namely:—The Red Pine timber to be of the first quality, fresh cut, good, sound, merchantable, and well-conditioned, from 11 to 15 inches square, averaging 12 inches, 20 feet and upwards, averaging not less than 30 feet in length, and the spine must be seen from the butt to the top on each of the four sides.

CHAPTER XXXIII.

AMERICAN PINES—(*Continued*).

YELLOW PINE (*Pinus Strobus*).

THIS tree occupies a very wide range in North America, and is found to spread from near the Saskatchewan River, in about 54° N., to the ridges of the Alleghany Mountains in Georgia, and from Nova Scotia to the Rocky Mountains. It is found in every part of New England, growing in every variety of soil, but flourishing best in a deep, moist, loamy sand.

In England it is called by botanists the Weymouth Pine, in compliment to Lord Weymouth, who first introduced it into this country; but in America it is commonly known as the White Pine, while the timber it yields is best known in commerce as the Yellow Pine. This tree may be distinguished by its leaves growing in tufts of five, by its very long cones composed of loosely-arranged scales, and, when young, by the smoothness and delicate light green colour of the bark. The trees are of erect growth and noble dimensions, many of them being 100 to 150 feet in height, and from 9 to 12 feet in circumference.

The wood is of a pale straw colour, soft, light (the specific gravity being only 435), and moderately strong. It has a clean, fine grain, works up with a smooth and

silky appearance, and is, on this account, in great favour with carpenters. It is very valuable for every description of joinery, where lightness may be desirable, and may be applied with advantage to many ornamental uses in both naval and civil architecture. For more substantial works of construction, it is not, however, considered to be so well adapted, as it is not sufficiently strong or durable for employment in them.

In every season's felling of the Yellow Pine trees, the straightest, longest, and finest pieces are sorted out and dressed or hewn nearly to the octagonal form; they are then called "Inch masts," and these rough spars are suitable for employment for the lower masts, yards, and bowsprits of ships.

It is essential to the qualification of the stick for mast, yard, or bowsprit purposes, that it be straight, sound, free from sudden bends and injurious knots. Further, it is important that the grain be straight, and especially it should be free from any spiral turn, as timber of that growth is liable to warp or twist out of shape after being worked. Nearly all the lower masts, yards, and bowsprits of large ships were formerly made of Yellow Pine; but, for the lower masts of small vessels, and generally for the topmast, topsail-yards, and other light spars where the strain is often sudden and great, this description of Pine was found to be not strong enough, and was therefore seldom employed.

The employment of Yellow Pine for large spars was chiefly owing to the difficulty experienced in obtaining the stronger Pines of sufficiently large dimensions, and it was only after the introduction of the "Douglas Pine" spars from the Oregon district of Columbia, that they were in some measure superseded. Still, the Yellow Pine wood, when made into masts, has generally proved

equal to the strains brought to bear upon it; the stays, shrouds, and other rigging being quite sufficient to hold it against any ordinary amount of pressure.*

After the spars have been withdrawn from each season's fall of trees, the remainder are hewn into a square form, producing logs varying from 14 to 26 inches square, and from 18 to 40 feet in length (Fig. 29). These pass through a sorting for quality, to suit the market, but there are no official brands by which the surveyor could at once identify them. Good, sound, practical judgment is therefore most essential for making a selection of this wood.

FIG. 29.

Occasionally we see quoted some "waney" timber for board purposes, or "waney board timber." These logs are not so perfectly hewn or squared as the ordinary timber, and are usually short butts of trees, which are very clean in the grain, free from knots, and solid at the centre. These are probably procured from fine trees that have been broken in their fall, and are doubtless about

* Masts made of Yellow Pine can seldom be relied upon after eight or ten years' work, especially if they have been used in the tropics, where the intense heat and rains deteriorate them very rapidly. Every care should therefore be taken to preserve them, first by painting them only after thorough seasoning, and then at intervals of a year or so. The covers at the wedging decks should also be carefully looked to, and kept in good condition, to prevent damp from affecting the mast at that part. The introduction of iron and steel for the lower masts of ships has now almost entirely superseded the use of wood, both in the royal and the mercantile navy.

the best that can be obtained for conversion into board.

In addition to the masts and timber, a few deals are imported. These are cut 3 inches thick, and vary in breadth from 9 to 24 inches, and occasionally even to 32 inches. In length they vary from 10 to 20 feet. They are sorted in Canada into three parcels, and designated first, second, and third quality, according as they are found free from knots, sap, defects, &c., &c., or otherwise. They are further denominated "bright" when passed direct from the saw-mills to the craft for shipment, in contradistinction to others, termed "floated," which are often brought over long distances on rafts, and get a little discoloured in their transit. They are commonly sold at per 120, St. Petersburg standard, and the price of the "floated" usually stands depreciated in the market to the extent of about 10 or 12 per cent. below the price of "bright" deals. A simple red chalk mark, thus—I., II., and III., drawn across the middle or side of the deals, is the only distinguishing brand they have to denote their quality.

Yellow Pine timber is subject to the cup and heart-shake defects, and there is also a slight degree of sponginess about the centre or early annual layers of the older trees, which detracts a little from their value. Further, the top end of the logs are often coarse and knotty, which renders that part unfit for conversion into small scantlings; but, otherwise, it is a good and profitable description of timber for use, in substitution for the heavier and harder Pines.

The subjoined tables of experiments on the strength of Yellow Pine will afford a means of comparison with other species.

TABLE CXLV.—YELLOW PINE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inches.	Inches.	lbs.	
1	2·00	1·75	4·50	630	424
2	2·00	1·65	5·00	636	432
3	2·00	1·85	4·50	684	464
4	1·75	1·65	4·50	660	444
5	2·25	2·00	3·75	552	435
6	2·75	2·10	5·75	598	411
Total . .	12·75	11·00	28·00	3,760	2610
Average .	2·125	1·833	4·66	626·6	435

REMARKS.—The whole of these broke with a moderate length of fracture and splintery.

The above-mentioned specimens were all of good quality, well seasoned, and taken from trees of 6 to 8 feet in circumference. It will be observed that the specific gravity and breaking strains varied only in a slight degree.

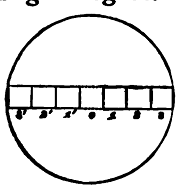

FIG. 30.

Experiments were also made to test the transverse strength of a series of seven pieces (Table CXLVI.) cut from a plank 2 inches thick, taken out of the middle or centre part of the butt-end of a tree, the centre piece ⊙ being made to include the pith (Fig. 30).

We are thus enabled to compare the strength of the earlier and the later growth of this wood.

TABLE CXLVI.—YELLOW PINE (CANADA).

Transverse Experiments.—2nd Example.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments. Direct cohesion on 1 square in.	Tensile Experiments. Number of the specimen.
	Inches.	Inches.	Inches.	lbs.			lbs.	lbs.	
7. 3	1·50	·50	4·25	508	568	537	127·0	2,660	3. 22
8. 2	1·25	·50	4·25	562	600	562	140·5	2,800	2. 23
9. 1	1·50	·50	2·25	480	537	536	120·0	2,485	1. 24
10. ⊙	2·25	1·10	2·75	360	430	502	90·0		⊙
11. 1′	1·85	·85	3·00	480	588	490	120·0	2,730	1′. 25
12. 2′	1·90	·90	4·25	512	568	541	128·0	2,800	2′. 26
13. 3′	1·75	·65	3·00	478	566	507	119·5	3,080	3′. 27
Total	12·00	5·00	23·75	3,380	3857	3675	845·00	16,555	—
Aver.	1·714	·714	3·393	482·85	551	525	120·71	2,759	—

The mean results of the experiments are as follows, viz.:—

The centre piece	⊙	s.g. 430	broke with	360 lbs.
,, next pieces	1 and 1′	,, 562	,,	480 ,,
,,	2 ,, 2′	,, 584	,,	537 ,,
,, outer ,,	3 ,, 3′	,, 567	,,	493 ,,

In the above example, there is something like a direct proportion existing between the specific gravity

and the strength, the densest wood having borne the greatest strain before breaking. Instead, however, of this point of density lying at the centre of the tree, as in the specimens of Oak that were tested in a similar manner, we find it, as is generally the case with other woods, about midway between the pith and the outer layers of duramen.

The results, if compared with the mean of the first-mentioned set of experiments on Yellow Pine (Table CXLV.), which were upon pieces taken from several trees, show that the tree from which the seven specimens were obtained possessed a little less strength, and rather less elasticity, than the former; but then it must be borne in mind that they were selected pieces, and probably did not include the weaker wood of either the oldest or the newest layers.

Further experiments were tried on six out of seven of the specimens, to ascertain their relative tensile strength (Table CXLVII., column 9). The following are the average results:—

The pieces 1 and 1′,	s.g. 562,	broke with	2,607 lbs.	on the square inch.
,, 2 ,, 2′,	,, 584,	,,	2,800	,,	,,
,, 3 ,, 3′,	,, 567,	,,	2,870	,,	,,

The centre piece ⊙ was not tried for tensile strength, as it was too much crippled under the transverse strain to be of any further value for experimental purposes.

The denser layers 2 and 2′, were not in this case quite so strong as 3 and 3′, which were of a less specific gravity.

TABLE CXLVII.—YELLOW PINE (CANADA).

Transverse Experiments.—3rd Example.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments. Direct cohesion on 1 square in.	Tensile Experiments. Number of the specimen.
	Inches.	Inches.	Inches.	lbs.			lbs.	lbs.	
14. 4	2·00	·65	3·00	504	562	538	126·00	2,485	4. 28
15. 3	1·75	·65	3·50	556	564	591	139·00	2,800	3. 29
16. 2	1·50	·50	4·75	665	530	753	166·25	2,870	2. 30
17. 1	2·25	·85	4·50	498	560	533	124·50	2,240	1. 31
18. 1′	2·25	·75	3·25	513	526	585	128·25	1,610	1′. 32
19. 2′	2·25	·85	2·75	419	566	444	104·75	2,150	2′. 33
20. 3′	2·50	·75	2·85	421	544	464	105·25	2,100	3′. 34
21. 4′	2·25	·65	3·00	460	564	490	115·00	1,820	4′. 35
Total	16·75	5·65	27·60	4,036	4416	4398	1009·00	18,075	—
Aver.	2·093	·706	3·45	504·5	552	549·75	126·125	2259·37	—

These experiments are similar to the last, but the specimens were taken from a larger tree, and the soft wood about the pith, including the heart-shake, was allowed to drop out. In this case the woody layers were placed vertically in the machine for testing them transversely (Fig. 31).

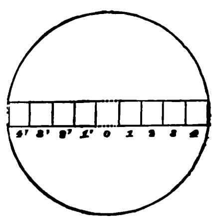

FIG. 31.

The mean results of the transverse experiments are as follows, viz. :—

The pieces	1 and 1′,	s.g.	543,	broke with	505	lbs.
,,	2 ,, 2′,	,,	548,	,,	542	,,
,,	3 ,, 3′,	,,	559,	,,	488	,,
,,	4 ,, 4′,	,,	563,	,,	482	,,

And of the tensile :—

The pieces 1 and 1′,	s.g.	543,	broke with	1,925 lbs.
,, 2 ,, 2′,	,,	548,	,,	2,510 ,,
,, 3 ,, 3′,	,,	559,	,,	2,450 ,,
,, 4 ,, 4′,	,,	563,	,,	2,152 ,,

We find here that the denser layers are at 4 and 4′, near the outside of the log, but we are not sure as to the amount of wood removed in hewing it, so that it may perhaps compare with the specimens in Table CXLVI. as to position of growth. It will be seen that the point of greatest transverse strength is at or near 3 and 3′, and that of the tensile at or near 2 and 2′.

There is a marked difference in the strength of the wood on the two sides of this tree, since 1, 2, 3, and 4 have a mean transverse strength of 566, and 1′, 2′, 3′, and 4′ of 453 only, the difference being 103, or about 18 per cent. This is further remarkable in the tensile strength, since 1, 2, 3, and 4 have a mean strength of 2599, and 1′, 2′, 3′, and 4′ of 1920 only, the difference being 679, or about 26 per cent.

TABLE CXLVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
36	2 × 2 × 30	464	7,280	1,820
37	2 × 2 × 30	444	7,840	1,960
38	2 × 2 × 30	506	9,205	2,301
Total . .	...	1414	24,325	6,081
Average .	...	471	8,108	2,027

TABLE CXLIX.

Vertical Experiments on Cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
39—42	3·625	6·750	15·75	22·875
43, 44	3·000	6·875	—	—
45, 46	2·125	7·250	—	—
47, 48	2·250	8·000	—	—
49, 50	1·875	8·000	—	—
51, 52	2·250	7·750	—	—
Total . .	15·125	44·625	—	—
Average .	2·521	7·437	15·75	22·875
Do. per in.	2·521	1·859	1·75	1·430

Vertical Experiments.—Four pieces, Nos. 53, 54, 55, *and* 56, *each* 2 × 2 *inches, and respectively*

	1	2	3	4 Inches in length.
Crushed with	8·5	7·454	8·25	7·875 Tons.

Contracts are annually made for the supply of Canada Yellow Pine timber, deals, and masts, yards, and bowsprits for the royal navy, according to the following specifications and conditions:—

The Yellow Pine timber to be of the first quality, 13 inches square and upwards, averaging 15 inches; 15 feet long and upwards, averaging 20 feet, and the spine must be seen from the butt to the top on each of the four sides.

The Yellow Pine deals to be of the first quality, bright, 3 inches thick, not less than 11 inches broad, and 12 feet long and upwards. The whole to be clean and free from sap.

* All the Yellow Pine masts, yards, and bowsprits to be perfectly straight, well and in a workmanlike manner wrought: the masts, yards, and bowsprits not to be hewn into eight squares, but all to be left in the square, similar to mast timber, and to have most of their sap taken out.

The masts, yards, and bowsprits are not to be tapered from their partners downwards, but to be kept as big at the heel as they are at the partners, and

* I am informed that this specification is not now in use, but I retain it as a suitable one for mast timber.

in their four squares as aforesaid; nevertheless, it is not expected that no sap shall remain at the edges of the said four squares; but it will be judged sufficient if such masts, yards, and bowsprits are capable of being cleared of sap when brought into their usual squares.

No mast, yard, or bowsprit to have large or sudden bites, or large knots, or any defects that may render them unfit to serve for the use for which they are required.

The diameter and length of the Yellow Pine masts, yards, and bowsprits to be in the following proportion :—

Mast pieces, 25 inches and upwards diameter, the length to be at least three times the diameter considered as feet; and under 25 inches to be three times the diameter considered as feet, with 9 feet added.

i.e. $25 \times 3 = 75$ feet. | $24 \times 3 + 9 = 81$ feet. | $20 \times 3 + 9 = 69$ feet.

Yellow Pine masts.—Head, or upper part	...	$\frac{2}{3}$	of the partners.
Hounds, or lower part	...	$\frac{4}{5}$	
3rd Quarter	...	$\frac{8}{9}$	
2nd Quarter	...	$\frac{20}{21}$	
1st Quarter	...	$\frac{60}{61}$	
Heel	...	as partners	

N.B.—Both partners are the bigness of the mast. Length of the head, $4\frac{3}{4}$ inches to every yard the mast is long; from the heel to the lower partners, one-sixth of the mast; ditto, upper partners, five-eighteenths.

The four quarters are divided between the upper partners and upper part of the hounds.

Yard pieces, the length to be at least 4 feet 3 inches for every inch of diameter in the slings.

i.e. $24 \times 4{\cdot}25 = 102$ feet. | $20 \times 4{\cdot}25 = 85$ feet.

Yards, 1st Quarter	...	$\frac{40}{41}$	of the slings.
2nd "	...	$\frac{9}{10}$	
3rd "	...	$\frac{3}{4}$	
Yard arms	...	$\frac{1}{2}$	

Bowsprit pieces, the length to be 2 feet for every inch of diameter at the bed, with 1 foot added.

i.e. $24 \times 2 + 1 = 49$ feet. | $20 \times 2 + 1 = 41$ feet.

End	...	$\frac{2}{3}$	of the bed.
3rd Quarter	...	$\frac{10}{12}$	
2nd Quarter	...	$\frac{10}{11}$	
1st Quarter	...	$\frac{40}{41}$	
Heel	...	$\frac{40}{41}$	

For setting off the lengths.

From the heel to the lower end of the bed, one-seventh of the bowsprit; to the upper end of the bed, three-eighths of the bowsprit.

1. *Quality.*—All the goods to be supplied under this contract to be of the best quality, fresh cut, good, sound, merchantable, and well-conditioned.

CHAPTER XXXIV.

PINES—(*Continued*).

AMERICAN PITCH PINE (*Pinus rigida*).

THIS tree, which must be distinguished from the very different *Pinus Australis* called Pitch Pine in the Southern States, is found spread over a wide tract of country lying between the Penobscot and the Mississippi rivers in North America. It is of erect and almost perfectly straight growth, and may be readily distinguished from the Pines hitherto considered by its leaves being in threes, by the rigidity and sharp edges of the scales of the cones, by the extreme roughness of its bark, and by the density of the brushes of its stiff and crowded leaves. It requires a good supply of moisture to bring it to the greatest perfection, and flourishes well on a sandy soil if mixed with loam.

The Southern States produce the best spars for masts, square timber, and plank, and these are shipped to this country chiefly from the ports of Savannah, Darien, and Pensacola, in the States of South Carolina, Georgia, and Alabama. The mast-pieces are generally of moderate dimensions, and take the place of Riga or Dantzic spars of 18 to 16 hands, whenever there is any difficulty in procuring either of those descriptions, and except that the Pitch Pine has a greater specific gravity, there is little to prevent it from being used more extensively than hitherto, in lieu of the Baltic Firs.

The timber is usually imported in well-hewn logs of 11 to 18 inches square by from 20 to 45 feet in length, the planks in thickness varying from 3 to 5 inches by 10 to 15 inches in width, and from 20 to 45 feet in length. Pitch Pine is employed in wood ship-building for beams, shelf, and bottom planking, &c., &c., and also in civil architecture wherever long, straight, and large scantlings are needed. It will not, however, make good board for joiners' general purposes, although we find it is used to some extent for cabinet work.

The wood is of a reddish-white colour, clean, hard, rigid, highly resinous, regular and straight in the grain, and, compared with most other Pines and Firs, is rather more difficult to work; it is durable and good in quality. The principal defects in Pitch Pine are the heart and cup-shake, the latter often extending a long way up the tree. Hence, as far as possible, logs having these defects should be used in large scantlings, to guard against a waste of wood near the centre.

TABLE CL.—PITCH PINE (AMERICAN).
Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·15	5·05	1,068	651
2	1·25	·15	3·75	902	630
3	1·00	·00	5·00	1,145	693
4	1·00	·00	4·65	1,005	662
5	1·25	·15	5·15	968	620
6	1·00	·00	5·15	1,207	698
Total . .	6·75	·45	28·75	6,295	3954
Average .	1·125	·075	4·791	1,049·16	659

REMARKS.—All the specimens broke with a short fracture.

The specimens Nos. 1 to 6 were selected pieces, but not all taken from the same tree.

The following were taken from a continuous strip cut the whole length of the tree.

TABLE CLI.—PITCH PINE (AMERICAN).

Transverse Experiments.—2nd Example.

(Butt to Top, inner part of the tree. Fig. 32*a*.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
7	1·25	·10	9·75	860	932
8	1·25	·00	5·00	1,020	764
9	1·25	·00	4·50	990	682
10	1·35	·00	4·25	874	652
11	1·25	·15	4·50	876	632
12	1·4	·00	3·25	715	586
Total . .	7·75	·25	31·25	5,335	4248
Average	1·291	·0416	5·208	889·16	708

REMARKS.—No. 7 fractured but not broken asunder, highly resinous; Nos. 8, 9, 10, and 11 broke a little short; 12 broke with a long splintery fracture.

Specimens Nos. 7 to 12, with the early layers or growth, were taken at about 3 inches from the pith of a centre plank cut from a log 42 feet in length. (Fig. 32.)

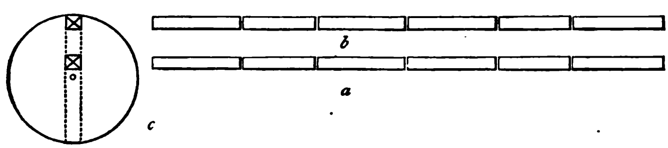

FIG. 32.—*a*, *b*, *c*.

TABLE CLII.—PITCH PINE (AMERICAN).

Transverse Experiments.—3rd Example.

(Butt to top, outer part of the tree. Fig. 32*b*.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.		
	Inches.	Inch.	Inches.	lbs.	
13	1·15	·00	3·75	1,035	840
14	1·15	·15	2·75	985	788
15	1·00	·00	5·00	1,110	760
16	1·25	·15	3·75	920	655
17	1·25	·00	4·75	925	613
18	1·35	·20	4·75	845	610
Total . .	7·15	·50	24·75	5,820	4266
Average .	1·191	·0833	4·125	970	711

REMARKS.—No. 13 broke short and split; 14, curl in the grain and broke short; 15 and 16 broke short and split; 17 and 18 broke with short fracture.

Specimens Nos. 13 to 18, with the later layers or growth, were taken from the outside of the same plank, the object being to ascertain in the two sets of experiments—Tables CLI. and CLII.—in which part of the length the maximum of strength lay. Table CLI. shows that in the early layers it is in specimen 8, the second piece from the butt-end; and Table CLII. shows that in the wood of later growth it is in specimen 15, the third piece from the butt-end. We also see in the mean results of the experiments that the strength of the inner is to the outer wood as 889 : 970.

Further experiments on the transverse strength of the inner and outer layers of wood of another Pitch Pine tree were then carried out, with the following results:—

TABLE CLIII.—PITCH PINE (AMERICAN).

Transverse Experiments.—4th Example.

(Butt to top, inner part of the tree.)

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
19	1·25	·00	4·50	760	583
20	1·50	·15	5·00	778	550
21	1·25	·00	3·75	752	531
22	1·50	·25	4·75	705	505
23	1·50	·25	4·75	695	501
24	1·50	·10	4·50	710	498
Total . .	8·50	·75	27·25	4,400	3168
Average .	1·416	·125	4·541	733·33	528

REMARKS.—Specimens all broke with fracture of a few inches in length.

TABLE CLIV.—PITCH PINE (AMERICAN).

Transverse Experiments.—5th Example.

(Butt to top, outer part of the tree.)

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
25	1·50	·10	4·75	805	601
26	1·25	·15	5·00	778	572
27	1·25	·05	4·25	742	533
28	1·50	·15	4·00	725	530
29	1·50	·05	4·00	739	528
30	1·50	·00	3·75	741	518
Total . .	8·50	·50	25·75	4,530	3282
Average .	1·416	·083	4·291	755	547

REMARKS.—Specimens all broke with fracture of a few inches in length.

Specimens 19 to 24, with the early layers, also 25 to 30, with the later layers of wood, were taken from a log of the same dimensions as the last, and under precisely the same conditions as those referred to in Tables CLI. and CLII., the results being nearly as before; that is, specimen 20, or the second piece from the butt-end of the early growth, and specimen 25, or the butt length of the later growth, are the two strongest pieces of the respective series. We also see in the mean results of the experiments that the strength of the inner is to the outer wood as 733 : 755. Thus the outside is as before, the strongest.

TABLE CLV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
31	2 × 2 × 30	693	16,800	4,200
32	2 × 2 × 30	630	17,640	4,410
33	2 × 2 × 30	651	19,320	4,830
34	2 × 2 × 30	620	17,920	4,480
35	2 × 2 × 30	662	19,600	4,900
36	2 × 2 × 30	698	20,720	5,180
Total . .	...	3954	112,000	28,000
Average .	...	659	18,666	4,666

TABLE CLVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 37.	No. 38.	No. 39.	No. 40.	No. 41.	No. 42.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·875	11·125	11·5	11·625	12·00	12·125	69·25	11·542	2·885

Other American Pines are :—

The Western White Pine (*P. monticola*), common in Columbia and Vancouver Island, but less valuable as timber than its Atlantic representative, *P. Strobus.*

The Sugar Pine (*P. Lambertiana*) of the Rocky Mountains and Pacific Coast. Its timber is large and valuable.

The Flexible Pine of Nevada, &c. (*P. flexilis*). The wood is very pliable, but too knotty and coarse for good work.

The Western Yellow Pine (*P. ponderosa*) of the Rocky Mountains and Pacific slopes, yields a very resinous heavy timber of large size, but not strong in proportion.

The Loblolly Pine of Carolina, &c. (*P. Tæda*), yields very poor timber.

The Short-leafed Yellow Pine of the Southern States (*P. Mitis*) has fine-grained, strong and durable wood, much used in carpentry in the States.

The Long-leafed Yellow Pine or Turpentine Tree of the Southern States (*P. Australis*) is by far the most important of the genus in the South. The wood is red and resinous, and most of the resin in America comes from it. It is much used and exported as Pitch Pine, and must be distinguished from the Northern *P. rigida* of Canada, &c., which is exported under the same name.

CHAPTER XXXV.

AMERICAN CONIFERS—(*Continued*).

WE now pass to the Firs, which are distinguished botanically from the Pines by their leaves being isolated, and by differences in their cones.

OREGON OR DOUGLAS FIR (*Pseudo-tsuga Douglasii*).

This noble and gigantic species of Fir* is, according to Mr. Douglas, to be found in large forests in North-Western America, stretching from 43° to 52° of north latitude, and is the most important Conifer of Canada and the North-West. It is an evergreen of erect growth, varying from 100 to fully 200 feet in height, and from 5 to 25 feet in circumference, and occasionally even exceeding this measurement in girth. The bark is rough, and varies from 1 to 2 inches in thickness.

The wood is reddish-white in colour, close, straight, and regular in the grain, tough, elastic, has very little alburnum or sap-wood, and is remarkably free from knots, it being no uncommon thing to find pieces 70 to 80 feet in length without a single one upon the surface. In general appearance it more closely

* Often called the Oregon Pine.

resembles the Red Pine (*Pinus resinosa*) of Canada than either of the other Pines and Firs with which we are acquainted. It is, however, slightly harder than the Red Pine, and less firm in texture.

The Oregon Fir or Pine is rather more rapid in its rate of growth than the Firs and Pines generally are, and makes about 24 inches in diameter in a hundred years, or, as I have proved by an average of several specimens, it makes 1 inch diameter of wood in 4·32 years.

Cargoes of Oregon Fir spars are occasionally brought to this country, together with a little timber and plank; but it can scarcely be said that there is as yet any regular trade kept up in this wood, owing chiefly to the great cost of transport, the heavy freight charges preventing its importation and successful competition with the Canadian and Baltic Firs, which can be put upon the London market at less expense.

The Oregon spars are generally well dressed, or manufactured for the market, are perfectly straight, and vary from about 10 inches in diameter and 40 feet in length, to 32 inches in diameter and 110 feet in length. They are much sought after, and are well adapted for lower-masts, yards, and bowsprits, &c., &c.; for yachts, and for the royal and mercantile marine. For top-masts, however, where there is often much friction, they are not so well suited as Riga or Dantzic Fir, or the Kauri Pine of New Zealand, owing to the want of cohesion in the annual layers.

A good specimen of the Oregon Fir, 159 feet in length, was placed in the Royal Botanic Gardens at Kew for a flagstaff, about the year 1861, and has shown excellent service there. One or two such spars, suitable for flagstaffs, the dimensions varying from 9 to 14 inches

in diameter, and 80 to 110 feet in length, are commonly brought with each cargo.

The present price (1875) of these Oregon Pine spars for masts, &c., varies from £7 10s. to £11 10s. per load of 50 cubic feet, according to size. This is in excess of that usually charged for the Yellow Pine of Canada, but, looking to the superior manufacture of the Oregon spars, the actual difference in cost is very small indeed.

For the square timber and planks, which are brought as stowage goods with the spars, no quotations are given, and, in a general way, they must always be ruled by the market price for Canadian and Baltic square Fir timber.

The clean appearance and straightness of the Oregon Fir timber are quite sufficient to recommend it for many purposes in carpentry, and it certainly may be used with advantage in both naval and civil architecture, in lieu of the more well-known Firs. The specific gravity of this wood, when seasoned, is about 605.

OTHER NORTH AMERICAN FIRS.

There are several kinds of Firs in North America, namely, the Hemlock Spruce (*Tsuga Canadensis*), which has small, pointed, pendulous terminal cones, and thin, flat leaves, one of the commonest and most useful, though coarse timbers; the Black or Double Spruce (*Picea nigra*), with dependent, egg-shaped cones, the scales being waved and jagged at the edges; and the White or Single Spruce (*Picea alba*), which has longer cones, spindle-shaped, also dependent, with the scales smooth and entire on the edge.

The White Spruce are the only deals shipped to this country from Canada as a clearly-defined class, all others being simply known here as Canadian, St. John's, &c. Spruce.

The London market was supplied with about 1,100,000 Spruce deals in 1871, 1,080,000 in 1872, 2,000,000 in 1873, and the immense quantity of 2,300,000 pieces in 1874, prepared generally in dimensions of 3 inches thick, 9 inches broad, and 12 to 21 feet in length. The bulk of these were sorted by brackers previous to shipment into first, second, and third qualities. Those of the first quality are perfectly clean, sound, and free from knots, sap, and defects; the second quality is also sound, and tolerably clean, but includes deals with a few knots and some sap upon the edges; while the third quality includes and admits all the faulty and coarser descriptions of deals, and some of them are very rough indeed.

As a rule, there is no brand other than a red chalk mark drawn once, twice, or thrice across the deal, to distinguish between the several qualities, and it is necessary that a careful inspection should be made before purchasing them. The relative values of the Canadian and New Brunswick Spruce deals in the London market are about as follows, viz., the 1st quality Canadian is to 1st quality New Brunswick Spruce as 1·0 : ·82; the 2nd and 3rd quality Canadian is to 2nd and 3rd New Brunswick Spruce as 1·0 : ·90; and these figures indicate approximately the difference in their respective qualities. All these deals are employed extensively in carpentry, ship, and engineering works.

TABLE CLVII.—SPRUCE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1	1·25	·06	6·25	696	451
2	1·20	·05	5·00	719	485
3	1·15	·04	3·75	556	510
4	1·30	·07	5·75	709	490
Total . .	4·90	·22	20·75	2,680	1936
Average .	1·225	·055	5·187	670	484

REMARKS.—No. 1 broke with about 12 inches length of fracture; 2, 3, and 4 with only a little less.

TABLE CLVIII.

Tensile Experiments.

(Dimensions of each piece, 2 × 2 × 30 inches, s.g. 484.)

—	No. 5.	No. 6.	No. 7.	No. 8.	Total.	Average.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight the piece broke with	13,104	19,040	13,440	17,360	62,944	15,736
Direct cohesion on 1 square inch	3,276	4,760	3,360	4,340	15,736	3,934

TABLE CLIX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
9·00	8·875	7·75	8·875	8·75	8·75	52·00	8·666	2·166

Other American Spruces are, *P. Engelmannii*, with an excellent durable timber, in the Northern States and Canada; the Rocky Mountain Blue Spruce (*P. pungens*); and the Californian Coast Spruce (*P. Sitchensis*), with coarse but strong and useful timber.

There are also several true Firs, some of which are extremely ornamental, such as *Abies nobilis*, a Canadian species yielding very good timber, and *A. amabilis*, the Western Silver Fir. The Red Fir of the Californian Sierras (*A. magnifica*) is said to yield strong and durable wood, but the timber of the American Silver Firs is not much valued as a rule.

North America also produces three species of Larch, of which the Tamarack or Hackmatack (*Larix Americana*) is best known; it is said to be tolerably abundant, and is found to range from the mountains of Virginia to Hudson's Bay.

In deep forests it sometimes attains a height of 60 and even 80 feet, but it is generally of small dimensions. The wood is of a reddish-grey colour, moderately hard, heavy, strong, and as durable as Oak. It is extensively employed in America in the framing, and generally in the construction of ships. Great curves and knee-pieces, however, can only be obtained from the spurs of the root and from the branches.

The American Red Larch (*Larix microcarpa*) is less abundant, and as a building wood is not much known. It is believed to be equal in strength and durability to the *Larix Americana*, with which, indeed, it occasionally passes without being detected.

Larix occidentalis, the Western Larch of Columbia, yields a coarse but strong and durable timber.

CHAPTER XXXVI.

ASIATIC AND AFRICAN CONIFERS.

THE CEDARS.

THE word Cedar, like the words Oak, Deal, and others, has been misapplied to several timbers which have nothing in common beyond more or less superficial resemblances in colour, texture, &c.* The true Cedars are Coniferous trees belonging to the family *Cedrus*, and of these there are three races or varieties, often regarded as species. The Cedar of Lebanon (*Cedrus Libani*) of Asia Minor, the Deodar (*C. Deodara*) of the Himalayas, and the Atlas Cedar (*A. atlantica*) found in North Africa.

It was not unnatural, perhaps, that the word Cedar should also be applied to certain fragrant woods yielded by the genus *Cedrela* and its allies, members of the Dicotyledonous family Meliaceæ, and, as matter of fact, the wood of *Cedrela odorata* of the West Indies has long been so termed. Moulmein Cedar is *Cedrela Toona*, the Toon of India; and *C. australis* goes by the name in Australia.

The matter is more complicated, however, by the name Cedar being applied to certain other Coniferæ, *e.g.*

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* See page 210.

Bermuda Cedar is *Juniperus Bermudiana**, and various allied species of *Thuja*, *Librocedrus*, and *Cupressus* are called Cedars in our colonies.

Cedar-wood is also the name given to *Icica altissima*, the timber used for making canoes in Guiana; while *Guazuma* in Jamaica, and *Dysoxylon* in Australia, are called Bastard Cedar, and there are other cases of the same misapplication of the word.

The following concerns the true Cedars.

THE CEDARS.

CEDAR OF LEBANON (*Cedrus Libani*)

is found upon Mount Lebanon, the Taurus, and also upon many of the mountains in Asia Minor.

It is a very stately and majestic evergreen tree, with heavy wide-spreading branches thrown out horizontally from low down the stem, bearing clustered leaves and erect obtuse oblong cones. Very extraordinary accounts

* Bermudian Cedar (*Juniperus Bermudiana*) is very small, and much lighter than that of Cuba. It was tried experimentally in the building of several brigs and schooners in the royal dockyards, before wood ship-building had passed into disuse, but with only partial success, and the use of it was soon discontinued. It is used in the Bermudas for the building of boats and small vessels, and is in request in this country for making of pencils.

The Cedar of Florida is similar in quality and texture to the Bermudian, and is well adapted for the same kind of employment.

The Spaniards formerly used Cedar to a great extent in ship-building; and the *Gibraltar* and other large ships of theirs were found, on being taken to pieces, to have much of this wood in them, in a sound state.

The same rule prevails in the market with reference to the sale of Cedar as with Mahogany, namely, that of deducting about one-third from the calliper measurement for irregularity of manufacture, shakes, defects, centres, saw-kerfs, &c.

Pencil Cedar is classed No. 3; Red Cedar, No. 6; and White Cedar, No. 17, among timbers used in ships, in Lloyds' rules for ship-building.

have been given of the longevity of these trees, but these should be received with some little reserve.

It is stated in a small work on useful and ornamental planting, that at Highclere Park, in Hampshire, the Earl of Caernarvon planted seeds in 1739, from a cone gathered upon Mount Lebanon. Only two germinated, which, after being planted out, remained rather stunted, and without showing any signs of vigour. In 1767 they were transplanted into a poor soil, in a bleak situation, being at that time 17 inches in girth at one foot from the ground, and from that date their growth was considered to be satisfactory.

No. 1 in	48	years measured	35	inches in girth at	3	feet from the ground.
,,	73	,,	82	,,	3	,,
,,	93	,,	111	,,	3	,,
No. 2 in	48	,,	22	,,	3	,,
,,	73	,,	72	,,	3	,,
,,	93	,,	102	,,	3	,,

These two Cedar trees, therefore, when 93 years old, measured respectively about 37 and 34 inches in diameter, and were making wood at the rate of 1 inch of diameter in about 2½ years. If this rate of growth is applied to the largest of the trees which Maundrell mentions that he saw upon Mount Lebanon, it would show them to be only about 350, or, at the most, 400 years old; and it is probable that this is somewhere about the limit of age which the Cedar trees attain, and not 3,000 years, as has been asserted.

We know very little of the quality of the timber of the Cedar of Lebanon; it is too scarce to find its way in any quantity into the markets of this country.

The wood is reddish-brown in colour, open and straight in the grain, very porous, soft and spongy in the centre, of light weight, and rather brittle; large and

injurious heart and cup-shakes frequently occur in it. It is deficient in strength, whichever way it is tried, but it works up easily, shrinks only moderately, and stands exceedingly well when seasoned. It is, therefore, of great value to the modeller, the carver, the toy-maker, and the general dealer in light and small wares. Large scantlings cannot, however, be worked out of it for framing in carpentry, neither is it suitable for such employment.

Cedar timber has long enjoyed the reputation of being durable; and there is no doubt that Solomon obtained the wood of *Cedrus* for employment in the fitments, if not in the more solid structure, of the Temple at Jerusalem. The wood has a pleasant though peculiar odour, which is obnoxious to insects and vermin, and articles made of this material are practically free from their attacks.

DEODAR (*Cedrus Deodara*).

This is a very large and tall tree of the North-West Himalayas, found between 4,000 and 10,000 feet, and extending into the mountains of Afghanistan and Beloochistan. The heart-wood is light, yellowish-brown, moderately hard, and distinctly fragrant, and the resin is not in distinct canals, though abundant. The annual rings are very even, and the quality of well-grown timber is excellent; in fact, it is the most durable and useful of the Himalayan Conifers, and must be regarded as by far the most important timber of North-West India, where it is employed for all kinds of construction —sleepers, bridges, carpentry, furniture, and shingles. More information, with tables of its mechanical properties, can be seen in Gamble's "Manual of Indian Timbers."

ATLAS CEDAR (*Cedrus atlantica*)

is met with in Morocco and on the Atlas Mountains of North Africa. Very little is known of its properties, but it is so closely allied to the foregoing that it may be inferred generally that the timber is very similar where well grown. As there can be scarcely any doubt that all the above three races of *Cedrus* have sprung from the same stock, I place them together, in spite of the fact that the home of the last named is North Africa.

THE CONIFERS OF INDIA.

I have already referred to the Himalayan Cedar, but the mountains of Northern India yield several other Coniferous trees of considerable importance in the country, though they are not exported.

Of the five Pines, the beautiful Bhotan Pine (*P. excelsa*) stands first in order of importance. It is remarkably like the North American Weymouth Pine (*P. Strobus*), and, like it, has its needles in fives, and its cones drooping and Fir-like. The wood, which has a red heart, is remarkably compact and durable, and contains much resin. In the districts where it is chiefly found—6,000 to 10,000 feet in the Himalayas—it is regarded as the most valuable timber of the country for buildings and engineering work, and its durability is second only to that of the Deodar.

Of the other Pines, the soft timber of *P. longifolia* is used for shingles, buildings, tea-boxes, &c., but it is not very durable. Perhaps its importance in producing resin is its chief value.

P. Khasya is the chief soft wood for building and other purposes in the Khasya hills. *P. Merkusii* is a

very resinous wood used for torches in Burmah. *P. Gerardiana* is found in North Afghanistan.

Of the Firs of India, the most important is *Picea Smithiana*, the Spruce Fir of the North-West Himalayas, Sikkim, &c., a tree with considerable resemblances to our European Spruce both in habit and in the qualities of its timber. The nearly white, non-resinous, soft, and easily-worked wood is largely used in Simla and other places for packing cases and rough carpentry, planking, &c.

The Himalayan Silver Fir (*Abies Webbiana*), which is found in similar districts to the last, is also in many respects the representative of our western species of Abies. Its white, soft, non-resinous, and easily-worked wood is not durable if exposed, but is used in some districts for shingles and construction.

Larix Griffithii is the Himalayan Larch, found in Nepal, Sikkim, &c., at elevations of 8,000 to 12,000 feet. The timber is much like our own Larch.

The Himalayan Cypress (*Cupressus torulosa*) yields a brown, streaked, fragrant, and moderately hard wood, used for building and other purposes.

Other Indian Conifers are the Yew (*Taxus baccata*), several species of Juniper, and *Podocarpus bracteata*.

The more important Conifers of the Cape and Natal are the Yellow-woods (*Podocarpus Thunbergii* and *P. elongata*).

The former, known as Upright Yellow-wood, is a large tree of first-class importance, yielding timber of a light and soft, but fairly strong and elastic character, easily split and worked, and used generally for all kinds of planks, beams, rafters, &c., and, properly treated with antiseptics, it makes good sleepers. The latter is known

as Outeniqua Yellow-wood in the Colony, and is neither so common nor quite so hard as *P. Thunbergii*, but it is used indiscriminately for the same purposes.

The Cedar Boom of the Cape Colonists (*Widdringtonia juniperoides*) is a light-coloured Cedar, useful for flooring and other carpentry, but perishable.

CHAPTER XXXVII.

THE CONIFERS OF AUSTRALIA AND NEW ZEALAND.

THERE are several excellent Coniferous timbers in Australia, of which the following are the most important. Several go locally by the name of "Pines," but there are no true Pines in Australia.

The Moreton Bay Pine (*Araucaria Cunninghami*) is not a true Pine, but a tree allied to the so-called "Monkey Puzzle" often planted in our gardens. It occurs in large quantities in the north of New South Wales and in Queensland, and is especially abundant on the Richmond river. The timber is light, straight-grained, and works very smoothly; it is very strong and durable if kept wet, but soon decays if exposed to alternations of damp and dryness. It is of considerable importance as an export timber, especially that from the hills away from the coasts. In addition to its uses in carpentry, for flooring, lining boards, &c., it is employed for cabinet work, and to some extent for spars.

The allied Bunya-Bunya (*A. Bidwilli*) of Queensland is less used as timber, on account of its seeds being eaten by the natives, but the wood is strong and good for framing, &c.

Dacrydium Franklinii, known in Tasmania as the

Huon Pine, yields a light tough wood, which has been used for whale boats, &c., and is said to be very durable. It is, however, somewhat scarce, owing to the great demand for so useful a timber.

One of the most important coniferous timbers of Australia is that of *Frenela robusta*, the "Black Pine," or Cypress Pine of Western New South Wales, but common all round the continent. It is not a true Pine, but a Cypress, and its fragrant, beautifully-marked wood is largely used for all kinds of carpentry and furniture work. It is regarded as an excellent and durable wood, very resistant to teredo and white ants, and therefore much valued for telegraph poles and railway work, as well as for boats.

The closely allied "Murray Pine" (*F. Endlicheri*) of Victoria and Queensland is very similar, and almost equally valuable; as are also the timbers of several related species of *Frenela* (*F. rhomboidea, F. Macleyana, F. Parlatorei*, &c.).

Another excellent timber is the Australian "Pencil Cedar" (*Podocarpus elata*) of New South Wales and Queensland. Close-grained, but soft and easily worked, and with beautiful figuring, this wood is much prized for joinery and cabinet work.

NEW ZEALAND CONIFERS.

KAURI, OR COWDIE PINE (*Dammara Australis*),

is a native of and is found only in New Zealand, and is the finest forest-tree in the colony. It is most plentiful about the middle part of the northern island, where there are very extensive forests of it, but it is only moderately abundant a little farther south, and towards

Wellington, and in the middle island, it is only sparingly met with. It is not a true Pine at all, but is allied to the "Monkey Puzzle" (*Araucaria*).

It is a tall and very handsome tree, with a slightly tapering stem, and reaches, in sheltered situations, a height of 100 to 140 feet, with a circumference of from 9 to 15 feet; and even much larger specimens are occasionally met with. At Wangaroa, a little to the northward of the Bay of Islands, I measured one that was 48 feet in circumference at 3 feet from the ground. It was a well-grown, healthy-looking tree, with a heavy cluster of branches thrown out at about 66 feet from the base, and these, spreading obliquely, covered a large space. Many others approximating in dimensions to this magnificent specimen were seen, but the largest that I ever met with was one standing near to Mercury Bay, which measured 80 feet to the branches, and 72 feet in circumference.

The Kauri is a slower-growing tree than most Firs and Pines; it is slower even than the Pitch Pine of America, and makes only 1 inch of wood diameter in about 6 or 7 years. Thus, the two noble trees to which I have referred were, by computation, respectively about 1,300 and 2,000 years old; they were, however, almost unavailable for any industrial purpose, as it would be impossible to move these excessively large trees if they were cut down.

The Kauri has a dense foliage of tough leathery leaves, resembling in shape those of the Box plant; they vary from ¾ to 1¼ inch in length, are sessile, and the fruit is a cone of a spherical form of about 3 inches in diameter, enclosed in which are the winged seeds. The bark is quite smooth, and about 1 inch in thickness. It is a peculiarity of this species of Pine, that a fluid gum,

or resin, of a milk-like character, oozes spontaneously out from every part of the tree, and hardens upon the surface by exposure to the air, immense masses of this opaque gum being often seen on old trees, suspended from the stem at the forked part of the branches.

Some few years since the British Government sent out several expeditions in succession to New Zealand, to procure spars fit for top-masts for line-of-battle ships, and it was while engaged on this special service that I first became acquainted with the properties of the Kauri Pine timber. Since the colonisation of that country, however, the business has been left to private enterprise, and spars, timber, and gum have occasionally formed part of the return cargoes of store and emigrant ships. Much more timber would, no doubt, have been shipped, were it not for the great expense that attends the working of the forests, and the cost of freight for so long a voyage. These two very costly items effectually preclude the Kauri Pine timber from competing with the Fir timber brought to this country from the Baltic, for ordinary building purposes.

Kauri Pine, when used for masts, yards, &c., is unrivalled in excellence, as it not only possesses the requisite dimensions, lightness, elasticity, and strength, but is much more durable than any other Pine, and will stand a very large amount of work before it is thoroughly worn out.

All the thriving and healthy trees have from 3 to 5 inches of alburnum or sap-wood very distinctly marked in them, even when fresh cut. The duramen or heart-wood is of a yellowish-white or straw colour, moderately hard for Pine, strong, clean, fine, close, and straight in the grain. It has a very pleasant and agreeable odour

when worked, planes up well, and leaves a beautiful silky lustre upon the surface, resembling, in some degree, the plainest Satinwood. It shrinks very little, and stands well after seasoning; further, it takes a good polish. It is, therefore, valuable for conversion into planks and boards, and is very suitable for cabin and other fitments in ships, for joiners' work generally, or for ornamental purposes.

It is also employed for the decks of yachts, as, from the regularity of its grain and the absence of knots, it looks much better than the Dantzic Fir that is commonly used. It wears, besides, more evenly, and does not require the reconciling or planing over, which is frequently found necessary if other woods are worked.

The Kauri Pine is generally sound, and free from the defects common to many other descriptions of timber; it very rarely has more than a slight heart-shake, even in old trees; the star and the cup-shake are also rare; it is, therefore, a remarkably solid timber, and may be considered one of the best woods for working that the carpenter can take in hand.

There are many experiments on the strength of the Kauri Pine, and the first to be noticed are on specimens taken from the butt-end of a log that was fully 60 feet in length and 22 inches square. A plank 2 inches thick having been taken out of the middle, it was cut to produce six pieces of 2 × 2 × 84 inches, four upon one side of the centre or pith and two upon the other (Fig. 33). The centre piece was excluded from the test as being of too weak a nature to bear comparison with the rest of the wood.

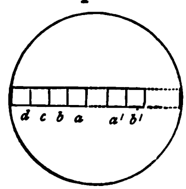

FIG. 33.

TABLE CLX.—KAURI (NEW ZEALAND).

Transverse Experiments.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.
	Inches.	Inch.	Inches.	lbs.	
1 *d*	1·25	·00	3·75	818	525
2 *c*	1·25	·15	4·25	875	529
3 *b*	1·15	·10	4·20	820	529
4 *a*	1·05	·00	3·75	750	520
5 *a'*	1·15	·10	3·40	760	515
6 *b'*	1·50	·15	4·15	870	562
Total . .	7·35	·50	23·50	4,893	3180
Average .	1·225	·083	3·916	815·5	530

REMARKS.—These specimens broke with a moderate length of fracture.

The table shows that transversely the strongest point was much nearer to the more recently-formed concentric circles than to the centre or pith of the tree. Subsequently, from the specimens above-mentioned, I obtained four serviceable pieces, 2 feet 6 inches in length, for the purpose of ascertaining their tensile strength, and found the maximum to lie in the piece marked *c* as before.

TABLE CLXI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7 *d*	2 × 2 × 30	525	16,244	4,061
8 *c*		529	20,440	5,110
9 *b*		529	17,920	4,480
10 *a*		520	18,080	4,520
Total . .	...	2103	72,684	18,171
Average .	...	526	18,171	4,543

TABLE CLXII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	3·125	10·75	24·5	45·75
15—18	3·500	10·00	24·5	48·00
19, 20	3·125	10·50	—	—
21, 22	3·000	10·75	—	—
Total . .	12·75	42·00	49·0	93·75
Average .	3·19	10·50	24·5	46·875
Do. per in.	3·19	2·625	2·722	2·929

Relatively considered, they stand as follows, viz. :—

TRANSVERSE STRENGTH.	TENSILE STRENGTH.
a = ·86	*a* = ·88
b = ·97	*b* = ·88
c = 1·00	*c* = 1·00
d = ·93	*d* = ·78

The specimens referred to in Table CLX., after being prepared for the experiments, lost 9 per cent. of their weight in the twenty days prior to breaking them, and seemed then to be in good seasoned condition for use.

A further series of experiments were made in a somewhat similar manner to that adopted with the

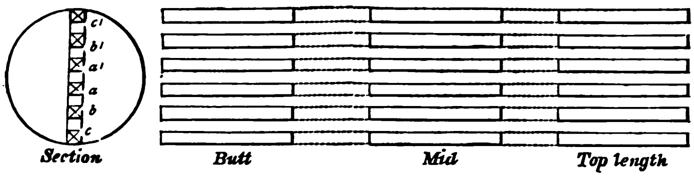

FIG. 34.

Pitch Pine; but in this case only three lengths were taken from a long Kauri tree—viz., one at the butt, one at the middle, and one at the top end, the intermediate pieces, each about 20 feet in length, being allowed to drop out. Six pieces were, however, taken from the breadth of each plank, three on each side of the pith (Fig. 34).

TABLE CLXIII.—KAURI (NEW ZEALAND).

Transverse Experiments.—Top length.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
23 c′	1·50	·15	3·50	660	534	741	165·0	—	—
24 b′	1·65	·20	3·50	630	560	675	157·5	—	—
25 a′	1·60	·00	2·25	490	580	507	122·5	—	—
26 a	1·40	·00	3·75	690	595	696	172·5	3,412	41
27 b	1·50	·15	4·25	660	540	733	165·0	3,220	42
28 c	1·60	·00	4·75	700	545	771	175·0	2,485	43
Total	9·25	·50	22·0	3,830	3354	4123	957·5	—	—
Aver.	1·541	·083	3·666	638·3	559	687	159·58	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

TABLE CLXIV.

Transverse Experiments.—Mid length.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments. Direct cohesion on 1 square in.	Tensile Experiments. Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
29 c'	1·50	·25	4·75	655	498	788	163·75	—	—
30 b'	1·65	·25	7·25	680	528	773	170·00	—	—
31 a'	1·40	·20	5·00	695	553	754	173·75	—	—
32 a	1·25	·15	4·50	740	560	793	185·00	3,290	44
33 b	1·35	·15	4·25	680	545	749	170·00	3,045	45
34 c	1·35	·25	4·00	705	556	761	176·25	3,045	46
Total	8·50	1·25	26·75	4,155	3240	4618	1038·75	—	—
Aver.	1·416	·208	4·458	692·5	540	769	173·125	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

TABLE CLXV.

Transverse Experiments.—Butt length.

Number of the specimen.	Deflections. With the apparatus weighing 390 lbs.	Deflections. After the weight was removed.	Deflections. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments. Direct cohesion on 1 square in.	Tensile Experiments. Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
35 c'	1·50	·15	4·00	760	550	829	190·00	—	—
36 b'	1·40	·15	3·75	710	580	734	177·50	—	—
37 a'	1·50	·20	4·00	705	560	755	176·25	—	—
38 a	1·25	·00	3·75	765	595	771	191·25	3,325	47
39 b	1·25	·15	3·00	640	580	662	160·00	3,080	48
40 c	1·35	·10	5·25	810	555	876	202·50	3,920	49
Total	8·25	·75	23·75	4,390	3420	4627	1097·50	—	—
Aver.	1·375	·125	3·958	731·66	570	771	182·91	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

Relatively considered, these experiments stand as follows :—

TRANSVERSE STRENGTH.		TENSILE STRENGTH.	
Top-length.		Top-length.	
$a - a'$ =	·87	$a - a'$ =	1·00
$b - b'$ =	·95	$b - b'$ =	·94
$c - c'$ =	1·00	$c - c'$ =	·73
Mid-length.		Mid-length.	
$a - a'$ =	1·00	$a - a'$ =	1·00
$b - b'$ =	·95	$b - b'$ =	·93
$c - c'$ =	·95	$c - c'$ =	·93
Butt-length.		Butt-length.	
$a - a'$ =	·94	$a - a'$ =	·85
$b - b'$ =	·86	$b - b'$ =	·79
$c - c'$ =	1·00	$c - c'$ =	1·00

and of the above the relative strength of the series are—

$a - a'$ =	·952	$a - a'$ =	1·000
$b - b'$ =	·932	$b - b'$ =	·937
$c - c'$ =	1·000	$c - c'$ =	·937

We find, also, the relative transverse strength of the three lengths is as follows, viz. :—

Top-length	=	·870
Mid ,,	=	·947
Butt ,,	=	1·000

and the specific gravity—

Top-length	=	·980
Mid ,,	=	·946
Butt ,,	=	1·000

The tables show that the maximum transverse strength lay in the outer series marked $c' - c$. It is not, however, certain whether the tree from which they were taken, although reduced to 22 inches square, would not have yielded a much larger square log, say 28 or 30

inches; and thus it seems probable that the point *c*, although nearer to the outside of this log than in the other, may, after all, be in about the same position in the tree. The experiments for the tensile strength show that the series $a' - a$ were the strongest.

Table CLXII. shows that the vertical strength of Kauri timber is about 2·8665 tons per square inch of base.

KAHIKATEA OR "WHITE PINE" (*Podocarpus dacrydioides*).

This majestic and noble-looking tree belongs to the group Podocarpeæ, allied to the Yews, and is in no sense a true Pine. It is a native chiefly of the temperate zone, and found abundantly in the close and dense forests of New Zealand, occupying many of the deep ravines, and generally preferring shelter and a low-lying moist situation to bring it to the greatest perfection.

It is of straight and lofty growth, frequently attaining a height of 150 to 180 feet, with a circumference of 6 to 15 feet. It is not an uncommon thing to meet with trees of this description, rising 60 feet and upwards in the stem, without a branch, and from thence to see them spreading out obliquely and forming a splendid conical top. The bark is dark brown in colour, rough, in strips, and also scaly; the lower portion of the stem being generally covered with moss.

The leaves are short, dark green in colour, narrow, rigid and erect, bristling evenly all round the branchlets. The fruit is a red berry, which the natives are very fond of; and it is said that a beverage, resembling in its anti-scorbutic qualities the well-known spruce beer, may be manufactured from the branches.* These trees are generally overrun with strong elastic creepers, of from

* Lindley's "Vegetable Kingdom."

4 to 6 inches in diameter, which intertwine with the branches, and, clustering there, render the whole a grand and densely thick mass of rich foliage.

The Kahikatea yields timber 12 to 30 inches square, and 20 to 60 feet in length. The wood is white in colour, light, straight in the grain, soft, and with little of the horny texture observable in the outer part of the concentric circles of the Fir and Pine species. It resembles the *Pinus Strobus*, or Yellow Pine of Canada, more closely, perhaps, than any other wood. It is easy to work, but is inferior in quality, being neither strong nor durable.

The natives of New Zealand sometimes make their canoes from this wood, as it is easily obtained. It does not, however, wear well, and, except for its buoyancy, and handiness upon the streams, has little to recommend it to notice. It is not employed in buildings if other timber can be readily procured. The Kahikatea is liable to be speedily attacked by a small worm. I found this to be the case with some specimens, after being only about six months in store.

The Kahikatea has sometimes been mistaken for the Kauri, it being similar in dimensions; when hewn, however, the quality is immediately seen to be inferior, and quite unfit for mast purposes. The specific gravity of the seasoned wood varies from 428 to 490, and averages about 460.

TANAKAHA (*Podocarpus asplenifolius*)

is found scattered over a large portion of the northern island of New Zealand, but is nowhere met with in abundance. It arrives at its greatest perfection on a dry soil and at a moderate elevation.

It is of straight growth, and attains a height of 60 to 80 feet, with a circumference of about 5 feet, the branches being thrown out nearly horizontally at about 30 to 40 feet up the stem, and forming above this a fine pyramidical head. The leaves are 1 to 1½ inch in length, and ½ to ¾ inch in breadth. The bark is thick, smooth, and of a dark brown colour: it is used by the natives to dye their garments either black or brown.

The wood is close and straight in the grain, and yellowish-white in colour, though not so light as that of the Kauri. It has a close resemblance to the Huon Pine of Van Diemen's Land. It works up well, is tough and very strong; so much so that the New Zealanders say it is the "strong man" among their forest trees.

The Tanakaha tree yields timber 10 to 16 inches square, and 18 to 45 feet in length, and is employed for masts, and for the decks of small vessels built for the coasting trade; it is found to answer admirably for these purposes, and is also valuable to the carpenter as a building material.

The specific gravity of the seasoned wood is about 600, but logs which have been only felled a few weeks, and therefore have their moisture only partially evaporated, will not float.

RIMU (*Dacrydium cupressinum*).

This tree, closely allied to the last, is found in many of the forests of New Zealand, and is one of the most magnificent of the vegetable productions of that country. It is tolerably abundant, prefers a rich alluvial soil, moisture and shelter, and is rarely seen upon dry or moderately elevated situations.

It is of straight growth, and attains a height of from 80 to 100 feet, with a circumference of 6 to 9 feet. It rises fully 40 to 50 feet clear of branches, above which they are thrown out in long, curved, pendulous forms. These, in their turn, give out numerous filamentary branchlets, surrounded with short, light green, thread-like leaves, the whole drooping, and exhibiting a very graceful appearance, and rendering the tree especially valuable for ornamental purposes.

The duramen, or heart-wood, is much varied in colour; for some few inches round the pith it is brown or chestnut, but beyond this it is lighter, with a nice diversity of shade and figure. It is moderately hard, but appears to be deficient in tenacity, it planes up smoothly, takes a good polish, and would be useful to the cabinet-maker for the manufacture of furniture.

The Rimu tree yields timber 10 to 30 inches square, and 20 to 50 feet in length; the natives employ it for their buildings and stockades, and occasionally for making canoes, but they swim rather heavily as compared with Kauri; they wear well, however, and last them a long time.

Several of these beautiful Rimu plants, which I brought to England in the years 1841 to 1843, Sir Wm. Symonds presented to the Royal Gardens at Kew, where, under the careful management of Sir Wm. Hooker, they grew up to be fine trees of 25 to 30 feet in height. They stood for many years, during the summer months, in large square cases or tubs in the open, and were greatly admired by the visitors, but, in the winter time, they were removed under shelter.

The specific gravity of the Rimu, when seasoned, is about 678.

MIRO OR "BLACK PINE" (*Podocarpus ferruginea*) is found in slightly elevated situations in many of the forests of New Zealand; it prefers shelter and a damp, although not an excessively moist soil, to bring it to perfection. It is of straight growth, and reaches the height of about 60 feet, with a circumference of 5 feet. The stem is clean, and rises to 30 or 35 feet clear of branches, above which they are thrown out nearly horizontally. The foliage is dark-green, very thick, and the leaves are about ⅛th of an inch in width, and 1 inch in length; the fruit is a red berry with a hard stone; it is a favourite food of the wood-pigeon.

The wood varies from light to dark brown in colour, is close in grain, moderately hard and heavy, planes up well, and takes a good polish. Some logs are nicely figured; it is, therefore, very suitable for cabinet-makers' work, &c. It would also be useful to the turner, and for any ornamental work, and as it yields timber 10 to 18 inches square, and 20 to 30 feet in length, it would, no doubt, be fit for civil architecture.

The specific gravity of Miro in a green state is 1214, but, when seasoned, varies from 660 to 752.

TOTARA (*Podocarpus totara*)

is of erect and straight growth, and attains the height of about 80 to 90 feet, with a circumference of 6 feet. It is tolerably abundant, and is found in many of the forests of the northern island of New Zealand. It is often met with upon the banks of rivers, where the tide washes its roots; but, generally, it seems to require shelter and a moderately moist soil to produce the finest trees.

It rises with a clean stem to about 35 to 40 feet, above which the branches are thrown out horizontally. The foliage consists of sharp-pointed dark-green leaves, of about 1¼ inch in length by ¼ inch in width; they are thick, rigid, and prickly to the touch. The bark is red in colour, and ringed at about 1 foot apart; the outer layers hang in thin long flakes; strips of this bark are often used as a thatch for roofing.

The Totara tree yields timber 10 to 22 inches square, and 20 to 45 feet in length. The wood is red in colour, close, straight, fine and even in grain, and is moderately hard and strong. It is probably the most valuable timber in New Zealand. It works up exceedingly well, and, although plain in appearance, would be found a good substitute for Mahogany, whether used for furniture, carpentry, or in the domestic arts. It might also be employed with advantage in civil architecture. The alburnum or sap-wood is generally from 2 to 3 inches thick on this description of timber, and is lighter in colour than the duramen or heart-wood.

The natives make their small and medium sized canoes of the Totara, and generally prefer that the rising strake of the larger ones, and especially those employed in war, should be of this wood, as it wears better than Kauri, and is considered durable. I gathered the information from several intelligent natives that in the southern districts there are very large forests of Totara trees, of sufficient size and length for masts of ships of 1,000 to 1,500 tons burthen.

When fresh cut the specific gravity of this wood is about 1230, but when seasoned it is only about 600.

The Kauri, Kahikatea, Tanakaha, Rimu, Miro, Totara, Rata, Pohutukawa, and Puriri trees are the principal, and, except the Kahikatea, probably the most

valuable of all that can be found in New Zealand. Still there are many other varieties, about thirty, some ten or twelve of which could be made available for building and cabinet purposes; the remainder would be more or less useful for the manufacture of agricultural implements, fuel, &c., &c.

Subjoined is the list of the New Zealand trees met with, in addition to those just described, and concerning which we want more information:—

1. Kahikatoa.*	10. Mohoi.	19. Mida.
2. Karoa.	11. Aki.	20. Tarata.
3. Tongiho.	12. Akipero.	21. Kohutuhutu.‡
4. Pugatea.	13. Towai.	22. Nana.
5. Wawaku.	14. Kohekohe.	23. Oroaka.
6. Kowai.	15. Matai.†	24. Kiwideah.
7. Kohehu.	16. Karaka.	25. Tototo.
8. Ramarama.	17. Tepow.	26. Manawa.
9. Pukapuka.	18. Tee.	27. Tawada.

* The Kahikatoa tree is of moderate dimensions, and yields a hard red wood; it differs widely from the Kahikatea tree described at page 397.

† *Podocarpus spicata* (Kew Catalogue).

‡ *Fuschia excorticata* (Kew Catalogue).

Part IV.

APPENDICES.

APPENDIX A.

SOME OF THE PRINCIPAL USES FOR WHICH TIMBER IS EMPLOYED.

TIMBER may be employed in the rough, or split, or sawn, or worked up in various ways.

(1.) For constructions, such as buildings, bridges, piers, &c., where great weights have to be supported, and the materials must be in large masses, strong and durable. Posts, baulks, rafters, staircases, sashes, &c., of all kinds come under this heading.

(2.) Piles and similar structures demand special properties of resistance and durability in contact with water, permanent or temporary, as the case may be.

(3.) Wooden pavements, exposed stairs, and wooden roadways of various kinds, as well as wooden protections to banks, docks, locks, &c., also require exceptional capacities for resisting wear and tear and exposure.

(4.) Railway sleepers and telegraph poles consume enormous quantities of timber in all countries; here, again, durability, hardness, and elasticity are demanded.

(5.) Palisading, fencing, shingles, &c., are purposes for which enormous quantities of split or sawn timber are consumed. The exposure of such wood to sun and rain, insects, &c., limits the kind to be employed considerably.

(6.) Pit-wood. Many thousands of tons of timber, in the form of props for shoring, are employed annually in mines of all kinds.

(7.) Sluice-gates, canal works, water-wheels, wet-slides, and many minor works under water require special kinds of timber.

(8.) Mills for oil, sugar, &c., pulleys, windlasses, &c., are largely made of wood in many parts of the world, and great care is needed in employing the right kinds for cogs, axles, crushers, &c.

(9.) Ship-building and boat-building of all kinds, in spite of the rapidly extending employment of metal, still demand (and will probably always do so) the selection and employment of enormous quantities of large timber, not only of special strength and durability, but also of peculiar shapes and sizes; this, moreover, apart from the numerous fittings — masts, spars, decks, oars, fittings, &c. — afterwards put into the vessels.

(10.) The necessities of waggon and carriage making of all kinds, including gun-carriages, barrows, hand-carts, railway and tram cars, sledges, &c., form another important market for timber. The naves (hubs), spokes, felloes of wheels, the shafts or poles, the panels, axles, and, indeed, all the parts require timber with properties specially suited for the particular purposes.

(11.) Timber for cooperage—staves, hoops, and head-pieces—for barrels, casks, pails, buckets, &c., is another special branch of the subject; and the various trades concerned demand very special properties, according as liquid, volatile, or dry goods of various kinds are to be in contact with the wood.

(12.) The demands for joinery or carpentry and cabinet-making are so various, that a long chapter would be required to enumerate them. Panelling, balusters, flooring, furniture, and house-decoration require many woods of various degrees of hardness, shades of colour, marking, &c. Veneers, carved

work, inlaid work, and ornamental work of all kinds have their special requirements.

(13.) Shingles, rudders and oars, treenails and pegs, skewers, drums, sieve-frames, hoops, band-boxes, wood for matches, match and other boxes, &c., may also be mentioned.

(14.) Musical instruments—violins, guitars, wind instruments, the sounding-boards of pianos, &c., are other instances where special qualities are demanded.

(15.) Lead and other pencils, penholders, &c., again consume enormous quantities of straight-grained soft woods.

(16.) Wood for turnery, moulding, engraving, and carving must also have special properties.

(17.) Packing-cases, tea-chests, opium-boxes, &c., are manufactured of soft woods readily suited for the particular purposes.

(18.) Agricultural implements, such as ploughs, harrows, hoes, spades, hay-rakes, forks, &c., form another class of cases where wood is largely used.

(19.) Lance-staves, broom-handles, tool-handles of all kinds, butchers' blocks, walking-sticks, and a host of other everyday implements remind us of other uses of various timbers.

(20.) Basket-making in all its various branches demands more kinds and quantities of wood than people are generally aware of.

(21.) Shavings of wood are used for packing and ornamental work of many kinds, and several devices are used for producing what is sometimes called wood-wool.

(22.) Wood-pulp. One of the newest applications of wood is in the manufacture of many kinds of paper, papier-maché, and thousands of articles are now made annually of various moulded preparations of this wood-pulp; these include not only toys, picture-frames, mouldings, &c., but even railway wheels have been made of it, pressed into steel frames.

(23.) The uses of wood for burning purposes are almost forgotten in this country, but in Germany and many parts of the Continent, and in other countries, especially India, a great

proportion of the foresters' care is exercised in producing timber for firewood.

(24.) Charcoal, not only for the manufacture of gunpowder, but also for many other purposes, is obtained by the burning of wood in closed stacks, and the charcoal-makers are by no means indifferent as to the species and quality of the timber used.

(25.) Lastly, we may refer to the numerous and increasing substances obtained by the distillation of the products of combustion of wood of various kinds. Various tars, pitch, wood-spirits, soot, &c., are still obtained by these means.

Enough has been said to illustrate some of the principal and various uses to which timber is applied in different parts of the world; that these will increase, rather than diminish, is very evident to all who watch the progress of events, whence we may safely conclude that the foresters' art is likely to flourish for a long time to come.

APPENDIX B.

TABLE CLXVI.

SHOWING THE USES OF THE PRINCIPAL WOODS DESCRIBED IN THIS WORK.

SPECIES.	WHERE GROWN.	USES.
Acacias . . .	Australia . .	Various purposes of construction, carpentry, and ornamental work.
Acle. . . .	Philippine Islands	Naval and civil architecture.
Aki	New Zealand .	Turnery, agricultural implements, clubs, and spears.
Alder . . .	Britain. . .	Carpentry, piles, packing-cases, turnery.
Angélique . .	French Guiana .	Suitable for constructive purposes in lieu of African, Mahogany, or Teak.
Angelim-vermetho .	Brazil . . .	Naval construction.
Annan . . .	Burmah . .	Constructive purposes generally, gun carriages, &c.
Araribo-ou-potomuju	Brazil . . .	Cabinet work, domestic arts.
Araribo-roza . .	,, . . .	,, ,,
Araucaria . .	Australia . .	Carpentry, cabinet and general work, spars, &c.
Ash, British . .	Britain. . .	Coach and wheelwrights' work, agricultural implements, domestic arts, turnery.
,, Australian .		
,, Canadian. .	Canada . .	As Ash, British, boats' oars, &c.
,, Cape . .	Cape . . .	
,, American. .	North America .	As Ash, British, boats' oars, best sort, &c.
Assegai-wood . .	Cape . . .	Furniture, &c.
Balata . . .	Trinidad . .	A substitute for plain or inferior African or Mahogany.
,, . . .	French Guiana .	A substitute for hard woods in architectural works, furniture, &c.
Basswood. . .	America . .	Cabinet work, &c.
Beech . . .	Britain. . .	Cabinet and chair making, piles, wedges, turnery.
,, Evergreen .	Australia . .	Furniture, joinery, &c.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Beefwood, or She Oak	Australia	Furniture, domestic arts.
Billian	Borneo	Turnery.
Birch	Europe	Cabinet work.
,, Canadian	Canada	,,
Black-butt		
Blackwood	Australia	Wheelwrights' and turners' work.
Blood-wood		
Blue Gum	,,	Architectural works, piles, fences, general purposes.
Boco	French Guiana	Constructive purposes, furniture, turnery.
Bow-wood	America	Waggon work.
Box	Europe	Engraving, tools, carving, &c.
Boxwood	Australia	Sheaves for pulleys, mallets, turnery, &c.
Brazilletto	Bahamas	
Buck-eye	... ...	*See* Horse-chestnut.
Buck-thorn	Europe	Turnery.
Cagüeryan	Cuba	Building.
Camara	Brazil	Boat-building.
Camphor, or Kapor	Borneo	Planks, beams, piles, constructive purposes generally.
Cape Ash	Africa	As Ash, but poorer quality.
,, Box	,,	Substitute for Box.
,, Ebony	,,	Fancy work.
Canella-preta	Brazil	Constructive purposes generally.
Carapo	Trinidad	A substitute for plain and inferior Mahogany.
Cedar, Cuba, Mexican, and Honduras	... ...	Cabinet work generally, cigar boxes, patterns, &c.
Cedar, Bermudian	... ...	,, boat-building, &c.
,, Florida	... ...	,, ,,
,, Pencil	... ...	,, pencil making.
Celery-topped Pine	Van Diemen's Ld.	*See* Pine.
Chalta	India	General purposes.
Champack	,,	Building.
Cherry	Europe	Pipes.
Chestnut	Britain	Carpenters', wheelwrights', and coachmakers' work, domestic arts, &c.
Chow	Borneo	Planks, beams, piles, constructive purposes generally.
Coach-wood	... ...	*See* Light-wood.
Cog-wood	Jamaica	Mill work, &c.
Cotton-tree	India	Packing cases, floats, &c.
Dalbergia	,,	Building, construction, cabinet work, sleepers, &c.
Diospyros	,,	Engraving.
Dog-wood	Grenada	Building.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Ebène	French Guiana	Furniture, domestic arts, turnery.
,, rouge	,, ,,	,, ,,
,, verte	,, ,,	,, ,,
Ebony	India	Carving, fancy work, &c.
Ekebergia	Cape	Similar to Ash.
Elm, Common	Britain	Ships' keels, bilge planks, wheelwrights' and carpenters' work, carving and turnery.
,, Wych	,,	Do., specially adapted for boat-building.
,, Dutch	,,	,, ,,
,, Canada Rock	Canada	Ship-building, coach and wheelwrights' work, domestic arts, &c.
Els, Red	Cape	Furniture.
Emu	Australia	Turners' work.
Eucalyptus	,,	Various species used for all kinds of work.
Fiddle-wood	Barbadoes	Carpentry, wheelwrights' work, &c.
Fir, Dantzic	Prussia	Constructive purposes generally, deck deals, masts, &c.
,, Eliasberg	North Europe	,, ,, cabinet work.
,, Saldowitz	,, ,,	,, ,, ,,
,, white wood	,, ,,	Common purposes in carpentry, packing-cases, &c.
,, Riga	Russia	Constructive purposes generally, superior for masts.
,, Swedish	Sweden	Constructive purposes generally, inferior to Dantzic or Riga.
,, Norway	Norway	,, ,,
,, Spruce	N. Europe and N. America	Light framing, floor boards, boats' oars and spars, scaffold poles, &c.
Forest light wood	Australia	Cabinet work.
Fustic	Bahamas	Cabinet and furniture.
Giant-gum	Australia	Carpentry.
Grapiapunha	Brazil	Naval and civil architecture.
Greenheart	Demerara	Keelsons, shelf pieces, and planking in ships, excellent for piles, &c.
Grignon	French Guiana	Civil architecture, domestic arts.
Guarabu	Brazil	Naval and civil architecture.
Gum, White	Australia	Constructive purposes in carpentry.
,, Brown	,,	,, ,,
,, Curly	,,	,, ,,
,, Red	,,	,, ,,
,, Swamp	,,	,, ,,
Hackmatack	North America	*See* Larch, American.
Hawthorn	Europe	Engraving.
Hickory	America	Carriage.
Hinan	Europe	Small work.
Honeysuckle	Australia	Furniture work, boat-building.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Hornbeam	Britain	Cogs in machinery, wheelwrights work, turnery, &c.
Horse-chestnut	Europe	Blind-wood, moulds, &c.
Incaranda-tan	Brazil	Furniture and ornamental work.
,, cabiuna	,,	,, ,,
Iron-bark	Australia	Ship-building, piles, agricultural implements, fencing, &c.
Iron-wood	Burmah	*See* Pyengadu.
Jarrah	Australia	Ship-building, piles, railway sleepers, agricultural implements.
Jenipapo	Brazil	Carpentry, domestic arts.
Juba	Havana	A substitute for Sâbicu, in ship-building, furniture, &c.
Kahikatea	New Zealand	Indoor work in houses, packing-cases, &c.
Kahikatoa	,,	Architectural works, piles, domestic arts, &c.
Kammone	Burmah	Constructive purposes generally.
Kamonpew	,,	,, ,,
Kapor	Borneo	*See* Camphor.
Kari	West Australia	Piles, railway sleepers, agricultural implements, &c.
Karra	Philippine Islands	Constructive purposes generally.
Kathitka	Burmah	A substitute for Mahogany.
Kauri or Cowdie	New Zealand	Cabinet, carpentry, masts, and ship work.
Kiwideah	,,	Wheelwrights' work, agricultural implements.
Kohekohe	,,	A substitute for Cedar, cabinet work, domestic arts.
Kowai	,,	Turnery, agricultural implements, clubs and spears.
Kranji	Borneo	Planks, beams, piles, constructive purposes generally.
Laburnum	Europe	Cabinet-making.
Larch, Italian	,,	All kinds of frame-work in architecture, piles, &c.
,, Polish	,,	,, ,,
,, Russian	,,	,, ,,
,, American	North America	,, ,, and ship-building.
Lauan	Philippine Islands	Naval and civil architecture, furniture, &c.
Light-wood	Australia	Carriage-making.
Lignum Vitæ	West Indies, &c.	Sheaves for pulleys, turnery, domestic arts, &c.
Lime	Europe	Furniture.
Locust-tree		*See* Robinia.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Macaranduba	Brazil	Employed in ship-building.
Maconatari	French Guiana	A furniture wood, &c.
Mahogany, Spanish	Cuba	Cabinet work, turnery, domestic arts, ship-building.
,, Honduras	... ...	,, ,,
,, Mexican	... ...	,, ,,
,, Nassau	... ...	Cabinet work, turnery, domestic arts.
,, St. Domingo	... ...	,, ,,
Maire		
Malatapay	Philippine Islands	Constructive purposes generally.
Mambog	,,	,, ,,
Mangachapuy	,,	,, ,,
Mangalo	Borneo	Naval and civil architecture.
Mapilia	Philippine Islands	Constructive purposes generally.
Maples	Europe	Cabinet-making, &c.
,,	Canada, &c.	,,
Margosa	... ...	*See* Neem.
Matai	New Zealand	Constructive purposes generally, furniture.
Meriquitiara	Brazil	,, ,,
Metteral	Zambesi	Substitute for Mahogany.
Mida	New Zealand	Agricultural implements, clubs, spears, &c.
Milk-wood, White	Cape and Natal	General purposes.
Miraboo	Borneo	Furniture.
Miro	New Zealand	Cabinet work, turnery, civil architecture.
Mocasso-cassa	Zambesi	Constructive purposes generally.
Mocua	,,	Ship and boat building, a crooked wood for knees.
Mocunca	,,	,, ,,
Mocundo-cundo	,,	Constructive purposes generally, masts.
Molavé	Philippine Islands	Cabinet work, ship-building.
Monangare	Zambesi	Wheelwrights' and block-makers' work, furniture.
Mora	Trinidad	Cabinet work, ship-building, piles, &c.
Morrunda	Zambesi	Ship and boat building.
Mugunda	,,	,, ,,
Mulberry	Europe	Cabinet work.
Musk	Australia	Furniture and turners' work.
Musk-wood, Red		
Mussangara	Zambesi	Ship and boat building.
Myall	America	Pipes.
Myrtle, scented	Australia	Carpenters' and wheelwrights' work
,, Red	,,	,, ,,
,, White	,,	,, ,,
,, Yellow	,,	,, ,,
,, Brown	,,	,, ,,

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Nectandria	West Indies, &c.	*See* Greenheart.
Neem	India	Furniture.
Oak, African	... ...	Ship-building, carpentry, cabinet work, turnery, &c.
,, Australian	... ...	
,, British	... ...	All kinds of constructive work, naval, civil, and military engineering.
,, Belgian	... ...	,, ,,
,, Cape	... ...	,, ,,
,, French	... ...	,, ,,
,, Piedmont	... ...	,, ,,
,, Turkey	... ...	,, ,,
,, American white	... ...	,, ,,
,, Italian	... ...	Similar to British, but not so generally useful.
,, Indian	Himalayas	Construction, &c.
,, Dutch	... ...	Similar to British, but not so generally useful.
,, Dantzic	... ...	Deck and outside planks for ships, cabinet work, domestic arts.
,, Riga	... ...	Cabinet wainscot work, domestic arts.
,, Spanish	... ...	Constructive purposes of the second class.
,, Live	North America	Ship-building, sills to window and door frames, mallets, &c.
,, Swamp white	,,	,, ,,
,, Rough or post	,,	,, ,,
,, Black	,,	,, ,,
,, Scarlet	,,	,, ,,
,, Baltimore	,,	Cabinet and church furniture, general purposes.
,, Canadian	,,	,, ,,
Olive	Europe	Turnery.
,, Cape		
Oregon or Douglas Fir	North America	Spars, masts, carpentry.
Pacouri-soufri	French Guiana	Furniture wood, domestic arts.
Padouk	Burmah	Constructive purposes generally, piles, &c.
Palo Maria	Philippine Islands	,, ,,
Panacoco	French Guiana	A strong wood for constructive purposes, furniture, &c.
Pangira	Zambesi	For ship and house building.
Pao-preta	,,	Cabinet work, turnery, &c.
,, ferra	,,	A ship-building wood, also for furniture.
,, ferro	,,	A substitute for Sabicu.
,, fava	,,	,, Mahogany.
Pao-de-pezo	Brazil	,, Lignum Vitæ.
,, setim	,,	Generally in the domestic arts.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Parewah	Burmah	Constructive purposes generally, piles, &c.
Pear	Europe	Instruments.
Peguy	Brazil	Ship-building, carpentry, &c.
Pencil-wood	Victoria	Lining boards.
Penthityah	Burmah	Constructive purposes generally, piles, &c.
Peppermint, brown	Australia	Constructive purposes generally, charcoal, &c.
,, white	,,	,, ,,
Peroba-pardu	Brazil	Ship-building.
,, branca	,,	,, furniture, domestic arts.
,, vermetho	,,	A substitute for Cedar or Mahogany.
Persian Lilac		
Pine, Red	Canada	Constructive purposes generally, masts, &c.
,, Yellow	,,	Cabinet and joiners' work, fittings, patterns, masts, &c.
,, Pitch	North America	Cabinet and joiners' work, outside planks for ships, masts, &c.
,, Oregon	West Coast of N. America	Constructive purposes generally, masts, &c.
,, Kauri	New Zealand	Cabinet and joiners' work, fittings, patterns, masts, &c.
,, Celery-topped	V. Diemen's Land	Constructive purposes in carpentry.
Pingow	Borneo	Planks, beams, piles, constructive purposes generally.
Pingue	Zambesi	A substitute for Lignum Vitæ.
Pink-wood	Australia	Constructive purposes, cabinet work.
Piquea-marfim	Brazil	Cabinet work, a substitute for Satin-wood.
Plane	America	Cabinet work.
Plums	Europe	Turnery.
Plum tree	Australia	Furniture, gun stocks, &c.
Pohutukawa	New Zealand	Ships' frames, carpentry, agricultural implements.
Pugatea	,,	Civil architecture, domestic arts.
Puriri	,,	Ships' frames, carpentry, agricultural implements.
Pyengadu	Burmah	Constructive purposes generally, piles, &c.
Quar	Cape	Cabinet work.
Queen-wood	Australia	Cabinet-making.
Raiz-de-Pingue	Zambesi	*See* Pao-preto.
Rata	New Zealand	Cabinet work, naval and civil architecture.
Red Els	Cape	Furniture, &c.
Rewarewa	New Zealand	Cabinet work, carpentry, piles, shingles, &c.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Rhododendron	America	Engraving.
Rimu	New Zealand	Cabinet work, civil architecture.
Robinia	America	Cabinet work.
Roble	Trinidad	Ship-building.
Rosewood	Brazil	Cabinet and pianoforte makers, domestic arts, turnery.
,, Indian	India	Furniture and cabinet work.
Rose, male	French Guiana	A furniture wood, useful in domestic arts.
,, female	,,	,, ,,
Russak	Borneo	Piles and building.
Sabicu	Cuba	Cabinet work, ship-building, domestic arts, turnery.
Saffron-wood	Cape and Natal	Furniture, boats, and general work.
Sal	India	Piles, sleepers, construction.
Sandal-wood	,,	Fancy work.
Santa Maria	Central America	Cabinet work, ship-building, domestic arts, turnery.
Sapodilla	Grenada	Furniture, cabinet.
Sassafras	Australia	Carpenters' and cabinet work, domestic arts, &c.
Satiné	French Guiana	Naval and civil architecture, cabinet work, turnery.
Securipa	Brazils	Constructive purposes generally.
She Oak	Australia	*See* Beefwood.
Shingle Oak	,,	Shingles.
Silky Oak	,,	General purposes.
Silver Fir	Europe	Carpentry.
Simarouba	French Guiana	A furniture wood, useful in domestic arts.
Sissoo	India	Construction, &c.
Sneeze-wood	Cape	Construction, carpentry, furniture, and general purposes.
Spindle-tree	Europe	Turnery.
Spruce	,,	Carpentry.
St. Martin	French Guiana	Naval and civil architecture, cabinet work, turnery.
Stink-wood	Australia	Cabinet work, domestic arts.
,,	Cape	
Stringy bark	Australia	Constructive purposes in carpentry, piles, fences, domestic arts.
Sugar Gum	... ...	Piles, sleepers, &c.
Suridri	India and Burmah	Boat-building.
Swamp Oak	... ...	*See* Beefwood.
Tamarind	India	Turning.
Tanakaha	New Zealand	Constructive purposes generally, masts, &c.
Tapinhonho	Brazils	Ship-building.
Taraire	New Zealand	Cabinet wood.

TABLE CLXVI.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Tarata . . .	New Zealand .	Agricultural implements, domestic arts.
Tawa . . .	,, .	Carpenters' and wheelwrights' work.
Tawada . . .	,, .	Cabinet work, turnery.
Teak, Burmah .	... ...	Applicable to all kinds of naval, civil, and military engineering, cabinet and carpenters' work.
,, Cape .		
,, Malabar .		
,, Siam .		
Tepow . . .	New Zealand .	Carpentry and wheelwrights' work.
Tewart . . .	Australia . .	Ship-building, piles, civil architecture.
Thingan . . .	Burmah . .	Constructive purposes generally.
Thitkado or Toon .	,, . .	Substitute for Cedar or Mahogany for furniture purposes.
Thitka or Kathitka .	,, . .	,, ,,
Tongiho . . .	New Zealand .	Boat-building, carpentry, &c.
Toon . . .	India . . .	Furniture and cabinet work.
Toraira . . .	New Zealand .	Carpenters' and wheelwrights' work.
Totara . . .	,, .	Cabinet work, ship-building, substitute for Mahogany in domestic arts.
Towai . . .	,, .	Constructive purposes generally.
Tulip-tree . .	America . .	Flooring and inside work.
Turpentine tree .	Australia . .	Ships' planks.
Vinhatico . . .	Brazils . . .	A substitute for Cedar.
Violet . . .	French Guiana .	Much prized by cabinet-makers, turners, &c.
Wacapou . . .	,, .	Substitute for Rosewood for furniture, &c.
,, gris . .	,, .	,, ,,
Wattle, Black . .	Australia . .	Agricultural implements, boats' oars.
,, Prickly .	,, . .	,, ,,
,, Silver . .	,, . .	,, ,,
Wawaku . . .	New Zealand .	Carpentry, wheelwrights' work.
Willows . . .	Europe . .	Barrows, carts, bats, basket-work, &c.
Yacca . . .	West Indies .	Cabinet work.
Yellow-box . .	Australia . .	Engraving.

APPENDIX C.

TABLE CLXVII.

Showing the woods which have been experimented upon, alphabetically arranged—their specific gravity, transverse, tensile, and vertical strength—abstracted from the tables accompanying the description of the various kinds.

Number.	Name of Wood.	Specific gravity.	Breaking Weights used for—					
			Transverse strain on pieces 2″×2″×72″ between bearings.	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces—			
					1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs.	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
1	African	993	1,108	7,052	4·900	4·573	4·388	4·000
2	Ash, English	736	862	3,780	...	3·109	—	—
3	,, American	480	638	5,495	...	2·453	—	—
4	Blue Gum, Australia	1029	712	6,048	...	3·078	—	—
5	Cedar, Cuba	439	560	2,870	...	2·000	—	—
6	Chow, Borneo	1116	975	7,199	...	5·621	—	—
7	Elm, English	558	393	5,460	...	2·583	—	—
8	,, Canada	748	920	9,182	3·312	4·062	4·097	3·859
9	Fir, Dantzic	582	877	3,231	3·146	3·172	3·097	2·992
10	,, Riga	541	600	4,051	3·312	2·109	1·770	2·179
11	,, Spruce, Canada	484	670	3,934	...	2·166	—	—
12	Greenheart, Demerara	1149	1,333	8,820	6·750	6·819	6·368	5·814
13	Hornbeam, English	...	...	6,405	...	3·711	—	—
14	Iron-bark, Australia	1142	1,408	8,377	...	4·601	—	—
15	Jarrah, ,, ...	1010	686	2,940	...	3·198	—	—
16	Kapor, Borneo	956	1,184	6,790	...	5·330	—	—
17	Kari, Australia	981	863	7,070	...	...	...	5·140*

* 6 × 6 × 6.

TABLE CLXVII.—*continued.*

Number.	NAME OF WOOD.	Specific gravity.	BREAKING WEIGHTS USED FOR— Transverse strain on pieces 2″×2″×72″ between bearings.	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces— 1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs.	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
	Kauri, New Zealand	530	816	4,543	3·190	2·625	2·722	2·929
18	,, ,, Top (2nd Ex.)	559	638	—	—	—	—	—
	,, ,, Mid (2nd Ex.)	540	693	—	—	—	—	—
	,, ,, Butt (2nd Ex.)	570	732	—	—	—	—	—
19	Kranji, Borneo	1029	1,483	10,920	—	—	—	—
20	Larch, Russian	646	626	4,203	2·875	2·672	2·174	2·663
21	Mahogany, Cuba	769	856	3,791	2·750	3·250	3·024	2·428
22	,, Honduras	659	802	2,998	2·806	2·750	3·044	2·820
23	,, Mexican	678	783	3,427	2·437	2·633	2·549	2·394
24	Molavé, Philippine Islands	1013	1,243	7,812	—	—	—	—
25	Mora, Trinidad	1087	1,326	9,240	...	3·812	—	—
26	Oak, Baltimore	747	723	3,832	...	2·630	—	—
	,, English	735	776	7,571	3·562*	3·411*	3·225*	3·151*
27	,, ,, (2nd Ex.)	886	837	...	2·396†	2·110†	2·217†	2·064†
	,, ,, (3rd Ex.)	862	484	3,837	—	—	—	—
28	,, French	976	878	8,102	...	3·547	—	—
	,, ,, (2nd Ex.)	1082	831	—	—	—	—	—
29	,, Dantzic	835	474	4,212	3·773	3·375	3·166	3·062
30	,, Modena	1109	843	—	—	—	—	—
31	,, Sardinian	990	758	...	...	2·604	—	—

* Seasoned. † Unseasoned.

TABLE CLXVII.—*continued.*

Number.	Name of Wood.	Specific gravity.	Breaking Weights used for— Transverse strain on pieces 2″×2″×72″ between bearings.	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces— 1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs.	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
32	Oak, Tuscan	1040	758	...	...	2·437	—	—
33	,, Spanish	1042	562	—	—	—	—	—
34	,, Rhenish	1026	659	—	—	—	—	—
35	,, White, American	983	804	7,021	3·166	3·109	2·500	2·060
36	Pine, Red, Canada	552	653	2,705	3·479	2·115	2·431	2·125
37	,, Yellow ,,	435	627	—	—	—	—	—
	,, ,, ,, (2nd Ex.)	551	483	—	—	—	—	—
	,, ,, ,, (3rd Ex.)	554	505	2,027	2·521	1·863	1·750	1·375
38	,, ,, Oregon	596	—	—	—	—	—	—
39	,, Pitch, American	659	1,049	4,666	...	2·885	—	—
	,, ,, 2nd Ex. Inner layers	708	889	—	—	—	—	—
	,, ,, 2nd Ex. Outer ,,	711	970	—	—	—	—	—
	,, ,, 3rd Ex. Inner ,,	528	733	—	—	—	—	—
	,, ,, 3rd Ex. Outer ,,	547	755	—	—	—	—	—
40	Sabicu, Cuba	917	1,293	5,558	3·082	3·961	4·140	3·922
41	Teak, Burmah	776	913	3,301	2·416	2·838	2·640	2·343
	,, ,, (2nd Ex.)	807	843	—	—	—	—	—
42	Tewart, Australia	1169	1,029	10,284	4·469	4·195	3·931	4·102
43	Pingow, Borneo	747	1,263	6,311	...	4·539	—	—
44	Pyengadu, Burmah	1176	1,273	9,656	...	5·208	—	—

APPENDIX D.

TABLE CLXVIII.

Showing the woods which have been experimented upon, arranged in numerical order of tensile strength, and the comparative tensile strength, English Oak being = 1·000. Abstracted from the tables accompanying the description of the various kinds.

NAME OF THE WOOD.	Numerical order of tensile strength.	Direct cohesion on 1 square inch.	Comparative strength, English Oak being = 1·000.
		lbs.	
Kranji	1	10,920	1·442
Tewart	2	10,284	1·398
Pyengadu	3	9,656	1·275
Mora	4	9,240	1·220
Elm, Canada	5	9,182	1·213
Greenheart	6	8,820	1·165
Iron-bark	7	8,377	1·106
Oak, French	8	8,102	1·071
Molavé	9	7,812	1·032
Oak, English	10	7,571	1·000
Chow	11	7,199	·951
Kari	12	7,070	·934
African	13	7,052	·931
Oak, White American	14	7,021	·927
Kapor	15	6,790	·896
Hornbeam	16	6,405	·846
Pingow	17	6,311	·832
Blue Gum	18	6,048	·798
Sabicu	19	5,558	·734
Ash, American	20	5,495	·725
Elm, English	21	5,460	·721
Pine, Pitch	22	4,666	·616
Kauri, New Zealand	23	4,543	·600
Oak, Dantzic	24	4,212	·556
Larch, Russian	25	4,203	·555
Fir, Riga	26	4,051	·535
,, Spruce	27	3,934	·520
Oak, Baltimore	28	3,832	·506
Mahogany, Cuba	29	3,791	·500
Ash, English	30	3,780	·499
Mahogany, Mexican	31	3,427	·451
Teak, Moulmein	32	3,301	·436
Fir, Dantzic	33	3,231	·427
Mahogany, Honduras	34	2,998	·396
Jarrah	35	2,940	·388
Cedar, Cuba	36	2,870	·379
Red Pine, Canada	37	2,705	·357
Yellow Pine, Canada	38	2,027	·267

APPENDIX E.

Table CLXIX

Showing the woods which have been experimented upon, arranged in numerical order of vertical strength, and the comparative vertical strength, English Oak being = 1·000, abstracted from the tables accompanying the description of the various kinds.

Name of the Wood.	Numerical order of vertical strength.	Vertical force required to crush 1 square inch of base.	Comparative strength, English Oak being = 1·000.
		lbs.	
Greenheart	1	15,275	2·000
Chow	2	12,591	1·648
Kapor	3	11,939	1·561
Pyengadu	4	11,665	1·527
Iron-bark	5	10,306	1·348
African	6	10,244	1·341
Pingow	7	10,167	1·331
Tewart	8	9,397	1·229
Elm, Canada	9	9,098	1·191
Sabicu	10	8,873	1·161
Mora	11	8,539	1·117
Hornbeam	12	8,312	1·087
Oak, French	13	7,945	1·040
,, English	14	7,641	1·000
,, Dantzic	15	7,560	·990
Mahogany, Cuba	16	7,280	·953
Jarrah	17	7,164	·937
Fir, Dantzic	18	7,105	·930
Blue Gum, Australia	19	6,995	·915
Ash, English	20	6,964	·912
Oak, White American	21	6,964	·912
Pine, Pitch, American	22	6,462	·847
Teak, Moulmein	23	6,357	·832
Mahogany, Honduras	24	6,160	·806
Larch, Russian	25	5,985	·783
Mahogany, Mexican	26	5,898	·772
Oak, Baltimore	27	5,891	·771
Kauri, New Zealand	28	5,880	·769
Oak, Sardinian	29	5,833	·763
Elm, English	30	5,784	·757
Ash, American	31	5,495	·719
Oak, Tuscan	32	5,459	·714
Fir, Spruce	33	4,852	·635
Pine, Red, American	34	4,738	·620
Fir, Riga	35	4,724	·618
Cedar, Cuba	36	4,480	·586

APPENDIX F.

TABLE CLXX.

Showing that in the conversion of 1,413,894 cubic feet of hewn or square timber (raw material), comprising the following descriptions, the average yield of converted material—*i.e.*, timber, plank, board, &c., &c.—per cubic foot was as stated against each species in column **A**; also that the average yield of slabs and sawdust, or difference between the cubic contents of the converted and the raw material was as stated in column **B**.

TIMBER.	A. Proportion of converted per one cubic foot of raw material.	B. Proportion of slabs and sawdust per one cubic foot of raw material.
Oak, various :—		
Italian	·649	·351
American, Baltimore	·648	·352
Sardinian	·646	·354
American White	·641	·359
French	·527	·473
English	·526	·474
Spanish	·520	·480
Substitutes for Oak, &c. :—		
Tewart	·681	·319
Sabicu	·674	·326
Greenheart	·605	·395
Mora	·555	·445
African	·519	·481
Mexican Mahogany	·721	·279
Cuba ,,	·634	·366
Honduras ,,	·596	·404
Cedar	·726	·274
Teak	·660	·340
English Elm	·531	·469
Canada ,,	·687	·313
Canada Yellow Pine	·705	·295
Dantzic Fir	·700	·300
Riga Fir	·677	·323
Canada Red Pine	·650	·350
American Pitch Pine	·640	·360
Russian Larch	·610	·390
Canada Spruce Deals	·796	·204
,, Yellow Pine Deals	·742	·258

APPENDIX G.

TABLE CLXXI.

Showing the modulus of elasticity, transverse strength, &c., of the woods experimented on.

Page.	Description.	Specific gravity.	Deflection with 390 lbs.	Set.	Net deflection. $\delta =$	Elasticity. E =	Breaking load. $w_1 =$	Transverse strength. $p =$
99	Oak, British (1)	735	3·375	·189	3·186	714,000	776	10,500
100	,, ,, (2)	886	1·604	·114	1·490	1530,000	837	11,300
102	,, ,, (3)	862·5	3·083	—	3·083	738,000	484	6,500
	,, ,, Mean of first two	810	2·489	·151	2·338	1122,000	807	10,900
	,, ,, Mean of the three	827·8	2·687	·101	2·586	994,000	699	9,400
125	,, French (1)	976·5	1·483	·041	1·442	1577,000	878	11,800
125	,, ,, (2)	1082·0	1·583	·125	1·458	1560,000	831	11,200
	,, ,, Mean	1029·5	1·533	·083	1·450	1568,000	854	11,500
131	,, Tuscan	1040·5	3·76	·133	3·627	630,000	758	10,200
132	,, Modena	1109·3	2·33	·075	2·255	1010,000	843	11,400
132	,, Sardinian	990·5	2·608	·125	2·483	920,000	758	10,200
137	,, Dantzic	836	5·00	·24	4·760	480,000	474	6,400
142	,, Rhenish	1043	3·54	·275	3·265	700,000	659	8,900
143	,, Spanish	1042	4·025	·25	3·775	600,000	562	7,600
169	,, American	982·8	1·916	·208	1·708	1330,000	804	10,900
172	,, Baltimore	746·8	1·475	·191	1·284	1770,000	723	9,800
198	Teak (1)	776·2	1·65	·083	1·567	1452,000	913	12,300
198	,, (2)	808·7	1·942	·083	1·859	1224,000	843	11,400
	,, Mean	792·4	1·796	·083	1·713	1338,000	878	11,800
205	Iron-wood	1176·3	·958	·033	·925	2460,000	1273	17,200

TABLE CLXXI.—*continued.*

Page.	Description.	Specific gravity.	Deflection with 390 lbs.	Set.	Net deflection. $\delta =$	Elasticity. E =	Breaking load. $w_1 =$	Transverse strength. $p =$
218	Chow	1115·6	·916	·025	·891	2550,000	975	13,200
219	Pingow	747·5	·775	·058	·717	3170,000	1263	17,000
221	Kranji	1029·3	·625	·025	·600	3790,000	1483	20,000
222	Camphor	956	·65	·046	·604	3770,000	1184	16,000
224	Molavé	1013	1·25	·166	1·084	2100,000	1243	16,800
301	Oak, African	993·3	2·25	·05	2·200	1030,000	1108	15,000
274	Greenheart	1149·0	2·15	·066	2·084	1090,000	1333	18,000
276	Mora	1086·8	2·037	·10	1·937	1180,000	1326	17,900
281	Sabicu	916·7	·958	·033	·925	2460,000	1293	17,400
259	Mahogany, Spanish	769	1·208	·025	1·183	1920,000	856	11,600
264	,, Honduras	659·3	1·916	·083	1·833	1240,000	802	10,800
267	,, Mexican	677·8	1·125	·058	1·067	2130,000	783	10,600
230	Eucalyptus or Tewart	1169·2	1·27	·108	1·162	1960,000	1029	13,900
237	Jarrah	1010	3·21	·133	3·077	740,000	686	9,300
240	Kari, Australian	981·3	1·01	·04	·970	2340,000	863	11,600
242	Iron-bark	1142	·94	—	·940	2420,000	1408	19,000
246	Blue Gum	1029	1·26	·10	1·160	1960,000	712	9,600
149	Ash, English	736	1·625	·050	1·575	1440,000	862	11,600
175	,, Canada	480	2·75	·125	2·625	870,000	638	8,600
155	Elm, English	558	4·9	1·3	3·600	630,000	393	5,300
179	,, Canada	748	1·75	·29	1·460	1560,000	920	12,400
320	Fir, Dantzic	582	1·625	·066	1·559	1460,000	877	11,800
332	,, Riga	541	1·292	·092	1·200	1900,000	600	8,100
378	Spruce, Canada	484	1·225	·055	1·170	1950,000	670	9,000
347	Larch, Russian	646·3	1·566	·175	1·391	1630,000	626	8,500
269	Cedar	439	2·266	·258	2·008	1130,000	560	7,600
353	Red Pine	553·5	1·666	·133	1·533	1480,000	653	8,800

TABLE CLXXI.—*continued.*

Page.	Description.	Specific gravity.	Deflection with 390 lbs.	Set.	Net deflection. $\delta =$	Elasticity. E =	Breaking load. $w_1 =$	Transverse strength. $p =$
360	Yellow Pine (1)	435	2·125	1·833	·292	7790,000	627	8,500
361	,, (2)	551	1·714	·714	1·000	2274,000	483	6,500
363	,, (3)	552	2·093	·706	1·387	1640,000	505	6,800
	,, Mean	513	1·977	1·084	·893	3901,000	538	7,300
		513	1·977	Neglect	1·977	1150,000	—	7,300
368	Pitch Pine (1)	659	1·125	·075	1·050	2170,000	1049	14,200
369	,, (2)	708	1·291	·042	1·249	1820,000	889	12,000
370	,, (3)	711	1·191	·083	1·108	2050,000	970	13,100
371	,, (4)	528	1·416	·125	1·291	1760,000	733	9,900
371	,, (5)	547	1·416	·083	1·333	1710,000	755	10,200
	,, Mean	631	1·288	·082	1·206	1900,000	879	11,900
392	Cowdie (1)	530	1·225	·083	1·142	1990,000	816	11,000
394	,, (2)	559	1·541	·083	1·458	1560,000	638	8,600
395	,, (3)	540	1·416	·208	1·208	1880,000	693	9,300
395	,, (4)	570	1·375	·125	1·250	1820,000	732	9,900
	,, Mean	550	1·389	·125	1·264	1810,000	720	9,700

NOTE.—The transverse strength is calculated from $p = \frac{w_1 l}{\frac{2}{3}bd^2} = 13\frac{1}{2}w_1$

The modulus is obtained from $E = \frac{390\, l^3}{48\, I\, \delta} = \frac{2274480}{\delta}$

APPENDIX H.

TABLE CLXXII.

Description.	Comparative elasticity. Mean of first two English Oaks unity.	Comparative transverse strength. Mean of first two English Oaks unity.
British Oak (1)	·64	·96
,, ,, (2)	1·36	1·04
,, ,, (3)	·66	·60
,, ,, Mean of (1) and (2)	1·00	1·00
,, ,, ,, the three	·81	·86
French Oak (1)	1·41	1·01
,, ,, (2)	1·39	1·03
,, ,, Mean	1·40	1·06
Oak, Tuscan	·56	·93
,, Modena	·90	1·05
,, Sardinian	·82	·93
,, Dantzic	·43	·59
,, Rhenish	·62	·82
,, Spanish	·54	·70
,, American	1·19	1·00
,, Baltimore	1·58	·90
Teak (1)	1·29	1·13
,, (2)	1·09	1·05
,, Mean	1·19	1·08
Ironwood	2·19	1·58
Chow	2·27	1·21
Pingow	2·83	1·56
Kranji	3·40	1·83
Camphor	3·36	1·47
Molavé	1·87	1·54
Oak, African	·92	1·38
Greenheart	·97	1·65
Mora	1·05	1·64
Sabicu	2·21	1·60
Mahogany, Spanish	1·71	1·06
,, Honduras	1·11	·99
,, Mexican	1·90	·97
Eucalyptus or Tewart	1·75	1·28
Jarrah	·66	·85
Kari, Australian	2·10	1·05
Iron-bark	2·16	1·74
Blue Gum	1·75	·88

TABLE CLXXII.—*continued.*

Description.	Comparative elasticity. Mean of first two English Oaks unity.	Comparative transverse strength. Mean of first two English Oaks unity.
Ash, English	1·28	1·05
„ Canada	·78	·79
Elm, English	·56	·49
„ Canada	1·39	1·14
Fir, Dantzic	1·30	1·08
„ Riga	1·69	·74
Spruce, Canada	1·74	·83
Larch, Russian	1·45	·78
Cedar	1·00	·70
Red Pine	1·32	·81
Yellow Pine (1)	6·94	·78
„ (2)	2·03	·60
„ (3)	1·46	·62
„ Mean	3·48	·67
Pitch Pine (1)	1·93	1·30
„ (2)	1·62	1·10
„ (3)	1·83	1·20
„ (4)	1·57	·91
„ (5)	1·53	·94
„ Mean	1·69	1·09
Cowdie (1)	1·78	1·01
„ (2)	1·39	·79
„ (3)	1·68	·85
„ (4)	1·62	·91
„ Mean	1·62	·89

APPENDIX I.

(Referring to Table CLXX., Appendix F.)

"Well-squared timber," as understood in the trade, is nearly die square, and admits of little wane on the angles at any part of the log. The yield of this is about ·68 per cubic foot of raw material, as shown in Appendix F against Tewart. Some woods, when exceedingly well squared, will often yield a little more; as Mexican Mahogany. Others again, which are imperfectly manufactured, yield considerably less per cubic foot; as African.

The figures against Oak, English, were obtained from the conversion of both "rough" and "sided," not square timber. Also the figures against Elm, English, were obtained from "rough," and not square timber.

The results given in the table were obtained from the conversion of timber for ship-building at Woolwich Dockyard. For civil architecture and engineering purposes the yield per cubic foot would probably be better, as there would be less waste in cutting to straight than to curved lines.

The advantage of the table will be manifest on trial, since, if the figures in column A, which stand against any one of the woods mentioned in the list, are used as divisors of the net quantity of converted timber material required for any purpose, the quantity of hewn or square timber, *i.e.*, raw material, which it is necessary to purchase to produce it, is readily found.

Example:—If 5,600 cubic feet of converted timber material (Dantzic Fir) are required, how much hewn or square timber will it be necessary to purchase to produce it?

In column A, against Dantzic Fir, is ·700; therefore $\frac{5600}{\cdot 700} = 8{,}000$ cubic feet.

Also, if the figures in column A are used as multipliers, the converted produce can be ascertained approximately of any known quantity of raw material upon hand.

Example:—8,000 cubic feet of hewn or square timber (Dantzic Fir) is $\therefore$ $8{,}000 \times \cdot 700 = 5{,}600$ cubic feet of converted timber.

Also, if the figures in column B are used as multipliers with the hewn or square timber, the approximate waste in the conversion of it will be obtained.

Example:—Dantzic Fir, $8{,}000 \times \cdot 300 = 2{,}400$ cubic feet waste in slabs and sawdust.

THE END.

ALPHABETICAL INDEX.

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